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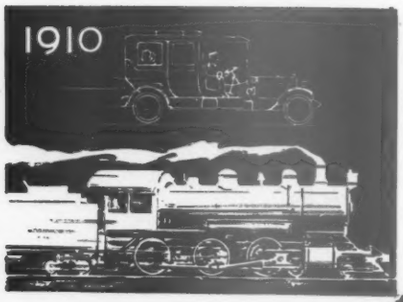

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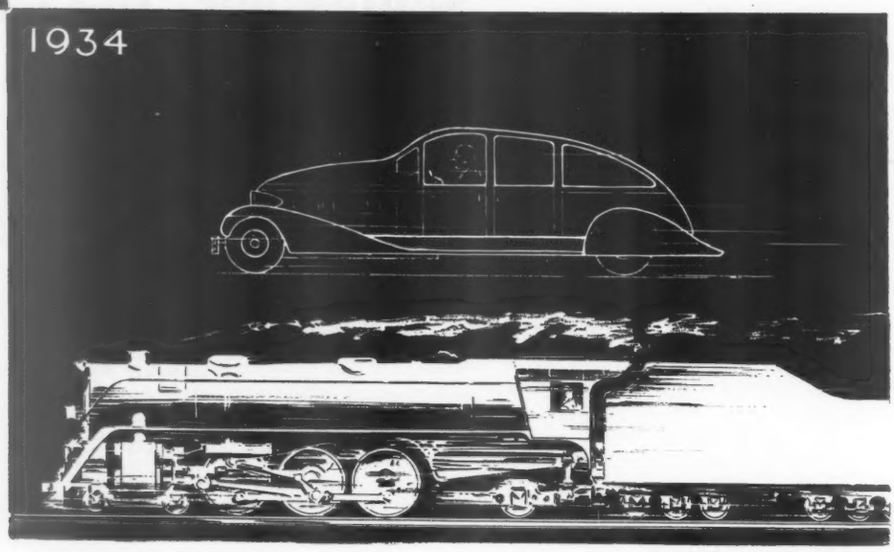

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Railway
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September - 1934

Westinghouse Builds 800-Hp., 110-Ton Diesel-Electric Switcher

Locomotive with 12-cylinder, V-type engine designed to provide maximum visibility and accessibility to working parts

ONE of the recent developments of the Westinghouse Electric & Manufacturing Company is an 800-hp., 110-ton Diesel-electric switching locomotive which was recently completed at its South Philadelphia Works. It incorporates many interesting features desirable for heavy switching or combined switching and transfer service, especial attention being given to the problem of providing maximum visibility for the operator and accessibility to all important parts.

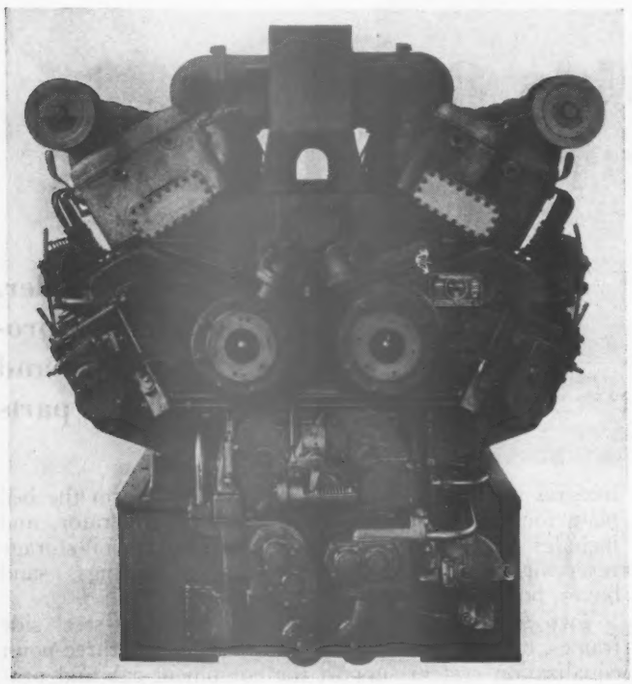
General Arrangement of the Locomotive

An elevated operator's cab centrally located, provides for uninterrupted vision over and along each side of the equipment hoods. The power plant is located in one hood and the engine-cooling system, air brake compressor, control equipment and battery are located in the other hood. The locomotive underframe consists of an integral steel casting, which is finished to form the bed plate for the Diesel engine and electric generator, and includes the engine sump and lubricating oil-storage reservoir, draftgear housing, bumper castings, sand boxes, body bolsters and center pins.

Two four-wheel swivel trucks having cast-steel side frames, cross-ties and bolsters and a modified three-point equalization system support the equipment cab and provide ample flexibility for negotiating yard tracks. The

Westinghouse 110-ton Diesel electric locomotive with 800-hp., 12-cylinder V-type engine

castings for the trucks were made by the General Steel Castings Corporation and the general truck assembly by the Baldwin Locomotive Works. The truck wheel base on this locomotive is 8 ft. and the axles have 7-in. by 13-in. journals. The boxes and brasses are lubricated by oil and waste and the center pins and side bearings by the Alemite system. The truck is of the outside-frame type with a long-fit solid bolted connection between the bolster and side frame and with bolted cross-ties at each end. The outside axle of each truck has a leaf spring over the box with inverted U hangers at each end of the spring which are connected at the bottom to the truck frame. The springs rest on inverted saddles that straddle the side frame and transmit the load to the boxes. The inside axle of each truck has the weight of the locomotive transmitted to it through a leaf spring in the same manner, but the outside ends of the two springs are joined together by a cross equalizer connected at the central point to the center of the truck cross-tie, this connection between the springs being directly over the end cross-tie. This method of suspension gives a modified three-point support with exceptionally good riding qualities.



End view of the engine showing the accessories

Two 12-in. by 12-in. brake cylinders are mounted on each truck, one cylinder being independently connected to the brake rigging on each side of the truck. A lever ratio of 8.3 is used, giving a braking effort equal to 85 per cent of the weight of the drivers at 59 lb. per sq. in. cylinder pressure. This arrangement eliminates brake beams and provides for proper shoe clearance while the brakes are released. Turnbuckles are provided for adjusting the piston travel for worn shoes and an additional fulcrum point is provided for use with worn tires. An auxiliary hand brake is connected to one truck for holding the light locomotive when standing.

The locations of the operator's seats and general arrangement of dual control and brake stands provides for operation of the locomotive in either direction from either of two operating positions without discomfort to the operator. This is accomplished by the use of swivel seats located next to the cab side windows, facing the longitudinal center line of the locomotive with control and brake pedestals, located directly in front of the operator, thus making all operating handles accessible while looking in either direction.

Steps and grab-handles are located at the four corners of the locomotive for climbing to the deck platform. Walkways along each side of the equipment hood lead to doors in the operator's cab. A platform at the other end of the locomotive provides access through a door to the engine room, through which one may pass to the operator's cab. The side steps and switchman's steps are illuminated by step lights.

Diesel Power Plant

The Westinghouse Diesel engine, develops 800 b.h.p. at 900 r.p.m. It has twelve cylinders arranged in V shape, each bank of cylinders being inclined at an angle of 30 deg. from the vertical plane through the crankshaft. It is of the solid injection type, using heavy fuel oil and operating on the four-stroke cycle principle.

An integral cast steel crankcase supports the crankshaft, cylinder heads, cylinder liners, and engine auxiliaries, Cored passages through the crankcases, fed from an oil header on the outer base flange, provide for pressure lubrication of the main bearings.

The crankshaft is forged from chrome nickel steel, machined throughout, counterbalanced, and is drilled for pressure lubrication of crank pins from main bearings. It is supported on the underside of the crankcase in seven main bearings. A friction disc type of vibration dampener is fitted on the front end of the shaft and the rear end is flanged for the flywheel mounting and generator coupling.

Removable liners of nickel cast iron are fitted in the crankcase. The upper end of the cylinder liner is clamped rigidly in place between the cylinder head and crankcase, and the lower end fits in heat-resisting, rubber-compound, water-seal rings. The liners may be readily withdrawn if required by a pulling bolt, inserted for this operation and a new assembly of liner and rings installed.

Each cylinder is provided with an individual cylinder head, cast from aluminum alloy with steel valve sets for dual inlet and exhaust valves. Brackets cast integrally with the head, support the rocker arm shafts. The valve operating mechanism consists of forged-steel rocker arms fitted with ball ends of heat-treated steel, arranged for adjusting valve clearances, and push rods, made from steel tubing, provided with sockets made from heat-treated steel. The entire mechanism is arranged for pressure lubrication.

In the upper and outer sections of the crankcase are cored out chambers for cam shafts, one for each bank of cylinders. The cam shafts are made from high-grade steel and heat treated. The cams are forged integrally with the shaft and ground to a master cam.

The pistons are of a special aluminum alloy, machined for pressure and oil control rings. The piston pins, of the full floating type are made from a special steel, hollow bored, polished, and fitted with aluminum end caps. The connecting rods are forged from steel, heat treated, and are fitted with bronze bushing for the piston pin, and a babbitted shell for the crank pin bearing.

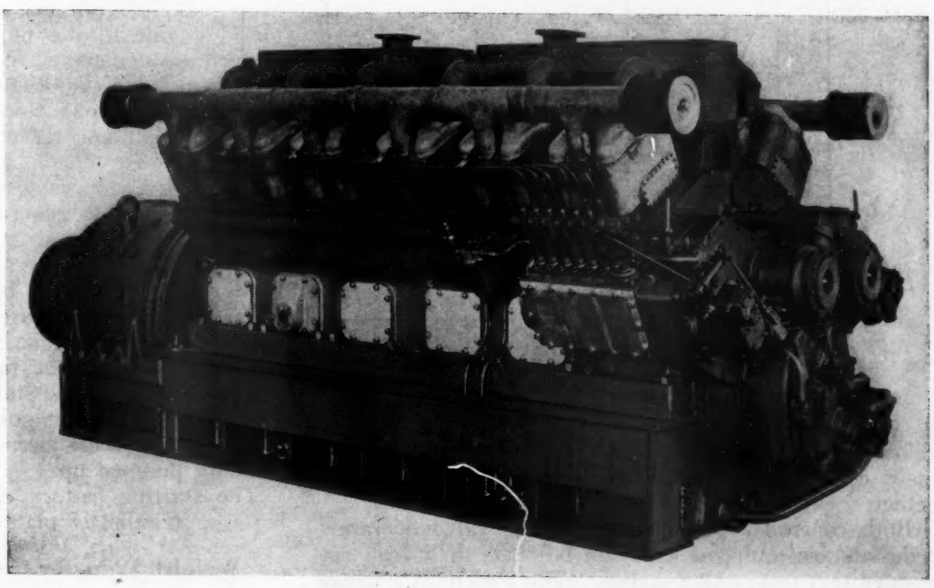
The fuel injection system has been developed especially for the Westinghouse line of high-speed Diesel engines. It consists essentially of a motor-driven gear pump, taking fuel oil from the main tank and delivering it to the main fuel pump headers, through an extremely fine mesh strainer at a pressure of approximately 30 lb.

per sq. in. One six-cylinder fuel pump is mounted on each side of the crankcase, and serves the bank of six cylinders adjacent thereto, or one fuel pump unit for each engine cylinder. The fuel pump operating shafts run at one half crankshaft speed, and their angularity with respect to the crank shaft, is advanced or retarded automatically to advance or retard the time of injection, dependent upon engine speed. Fuel oil is admitted from the oil header of the main fuel pump to the fuel pump cylinder during the downward stroke of the pump plunger, and the pressure developed in the pump cylinder during the upward stroke of the plunger unseats the atomizer needle valve when a pre-determined pressure is developed, and atomized oil is injected into the engine cylinder at the proper instant during the compression stroke, the volume of oil injected per stroke being automatically controlled by the governor. The atomizer, located in the center of the cylinder head, consists of a spring-loaded needle valve and nozzle having a number of very small holes drilled in the tip. The needle valve spring prevents injection of oil into the cylinder until the fuel pump plunger delivers the proper pressure for injection.

The engine governor is of the oil pressure type which has been used generally in marine service for many years. It is of the variable-speed type, thus permitting operation of the Diesel engine at any desired speed within its operating range and limiting the engine speed to that desired for the locomotive movement. Safety features provide for automatically stopping the engine in case of overspeed or reduction of lubricating oil pressure below a safe value.

General Dimensions of Westinghouse Diesel Electric Locomotive

Length inside coupler knuckles	42 ft. 6 in.
Length of operator's cab and hoods	35 ft. 6 in.
Overall width	10 ft. 2½ in.
Heights from rail:	
Overall (at operator's cab)	14 ft. 0 in.
Over equipment hoods at operator's end	12 ft. ½ in.
Over equipment hoods at coupler end	11 ft. 3 in.
Truck center distance	21 ft. 0 in.
Truck wheel base	8 ft. 0 in.
Diameter of drivers	3 ft. 0 in.



Westinghouse 12-cylinder, V-type Diesel engine developing 800 b. hp. at 900 r.p.m.

Electrical Transmission

A single bearing main generator converts the mechanical power at the engine shaft to electrical energy for use by the traction motors. The armature shaft is flanged and directly connected to a similar flange on the engine shaft with the web of the engine flywheel interposed between the two flanges. Both engine and generator shaft ends are machined to fit into the flywheel bore to insure concentricity and facilitate alignment. The outer end of the main generator shaft is carried on a self-aligning, non-thrust type ball bearing. The inner race is pressed on the generator shaft and the outer race has a sliding fit in the main generator bearing bracket, permitting the end thrust to be taken on one of the main bearings of the crankshaft.

The auxiliary generator frame is mounted on the main generator bearing bracket, and its armature on an extension of the main generator shaft. A fan, mounted on the engine flywheel draws air through the main and auxiliary generators, cooling both machines. The field of the main generator is excited from the auxiliary generator, while the field of the latter is excited from a storage battery. The main generator is used as a motor for cranking the Diesel engine during starting.

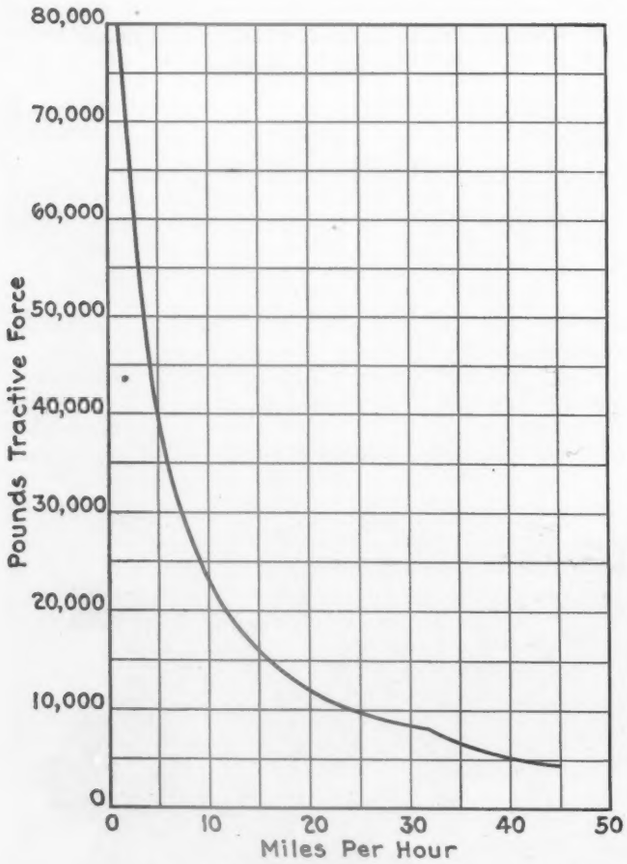
Four traction motors, utilizing the electrical power furnished by the main generator, supply the propelling force for the locomotive. One motor is geared to each of the driving axles through a pinion on the motor shaft and a gear on the driving axle. The gearing is spur type, machined from steel forgings and heat treated.

The traction motors are of the direct-current series type, self-ventilating, and equipped with roller-type armature bearings and split-sleeve type axle bearings. One side of the motor is supported on the axle bearings, the split-type bearing housing holding it in position to maintain the gear center distance and parallelism of gear teeth. The other side of the motor is flexibly supported on the truck crosstie, thus permitting the motor to follow the drivers in negotiating irregular track.

Control Equipment

The locomotive is equipped with Westinghouse dual control, developed especially for Diesel electric switching locomotives to provide maximum flexibility with one-man operation.

A pedestal-type controller and a brake valve operating pedestal are located at each of the operating stations. Their shafts extend through the cab floor, those on one side of the operator's cab being mechanically connected to the corresponding shafts of similar pedestals on the other side. One of the controllers is equipped with master control drums and the customary interlocking between the power and reverse levers, and the other is equipped with operating shafts only. A standard K-14 brake valve, minus the handles, is located directly



Tractive force-speed curve

below one of the brake valve operating pedestals with their corresponding shafts semi-rigidly connected together.

Both controller pedestals and brake valve operating pedestals are equipped with ball bearings to insure ease of operation from either station. The system as a whole provides maximum flexibility of locomotive operation in that the operator has complete control of locomotive power and reverse levers and automatic and independent brake levers at either operating station, and may move from side to side of the locomotive either before applying power, or while a locomotive movement is in progress, without shutting off power. This arrangement eliminates the use of transfer switches and cutout cocks, used ordinarily where two complete sets of controllers and brake valves are used, and enables the operator to take the position affording the best visibility of ground crew, tracks and surrounding conditions, at any time. The time elapsing between releasing hold of one set of control levers and taking hold of the second set of control levers need not exceed two to four seconds, and the high degree of visibility from the operator's cab permits this with safety in operation.

The power lever of the controller governs the operation of electro pneumatically operated switches, for closing and opening the electrical circuit between the main generator and the traction motors and an electro-pneumatic governor operator for increasing or reducing the speed of the Diesel engine with consequent increase or reduction in locomotive tractive effort and speed. A sliding handle on this lever permits changing either from the series connection to the parellel connection of the traction motors or from parallel connection to the series connection, with closed circuit transition, on any engine speed notch, without shutting off power. The last position of the power lever which may be taken only in the parallel position of the handle, provides for field shunting of the traction motors, with consequent increase in locomotive speed. On shutting off the power lever, a roller on the sliding handle engages a cam on the controller head and automatically returns it to the series position. The use of a single lever for controlling all power operations of the locomotive permits the operator to devote full attention to the ground crew and surrounding conditions. The reverse lever of the controller, controls an electro pneumatically operated reverser, which is located in the control compartment.

Engine loading is controlled over the range of generator voltage and current by the Westinghouse torque control system, developed several years ago for use on Diesel- and gas-electric locomotives and cars. It operates to regulate the generator field current and voltage to maintain constant horsepower output at the engine shaft over a wide range of tractive effort and speed. It also insures full speed operation of the engine at reduced engine torque in the event unusual conditions, result in a momentary reduction in engine torque. This system permits maintaining a constant voltage on the auxiliary generator for operation of the auxiliary motors, while the main generator voltage is varied to suit operating conditions.

Magnetically-operated contactors make and break the various circuits to generator fields and to the auxiliary motors. A meter and gage panel located in the operator's cab includes meters for indicating main generator voltage and amperes, battery amperes, engine-jacket water and oil temperatures, and lubricating oil pressure. Gages for the air brake system are located in separate boxes adjacent to the operator's seat.

The engine may be started or stopped from the operator's station without going into the engine hood, after the initial start has been made and main reservoir air pressure pumped up.

The starting battery consists of an Exide, Ironclad battery, 50 cells, 15 plates per cell.

Weight Transfer Compensating Equipment

The torque developed under load by all direct geared traction motors reduces the loading on the axle on which it is mounted for one direction of rotation and increases the loading for the other direction of rotation. This results in reaching the slipping point on the leading drivers of a truck before it is reached on the trailing drivers on the same truck. To develop maximum possible tractive force, it then becomes necessary to make the heavier loaded trailing drivers develop more tractive force than the lighter loaded leading axles. The Westinghouse system of adjustment for weight transfer, used on this locomotive, provides for doing this during maximum tractive force periods by use of a foot-operated push button, one of which is located at each operator's station, which energizes the operating coils of the field shunting switches of the loading motors on each truck, closing these switches, thereby reducing the torque developed by those motors to a value suitable for their axle loading

while the trailing motors work at or near the slipping point of their wheels. The position of the controller reverse drum automatically selects the group of field shunting switches to be closed.

Engine Cooling System

The quantity of heat to be dissipated in the engine-jacket water varies almost directly with the horsepower developed by the engine while the capacity of the radiator varies indirectly with the temperature of the air. Sufficient radiator capacity has been installed to permit continuous operation at full horsepower under the hottest weather conditions encountered without exceeding safe operating temperatures of jacket water and lubricating oil. Since average horsepower required from the engine varies with service conditions, and the air temperature varies with the season and climate, motor-driven blowers were adopted for force ventilating the radiator. The operation of one fan, ventilating the oil radiator and a part of the water radiator, is under the control of a thermostat located in the lubricating oil line while the operation of the second fan, which ventilates the remaining sections of the water radiator, is controlled by a thermostat located in the water lines. Auxiliary manual control of operation of blower motors has also been provided. The blower motors operate from the auxiliary generator, thus making their operating speed independent of the main generator voltage. Full voltage is available for their operation, at engine speeds as low as three-quarters full speed. This system provides for cutting in the blower sets only when their operation is actually required by temperature conditions, thus reducing to a minimum standby losses, incurred with fans driven directly from the engine and releasing full engine power for propulsion purposes during the greater part of the time.

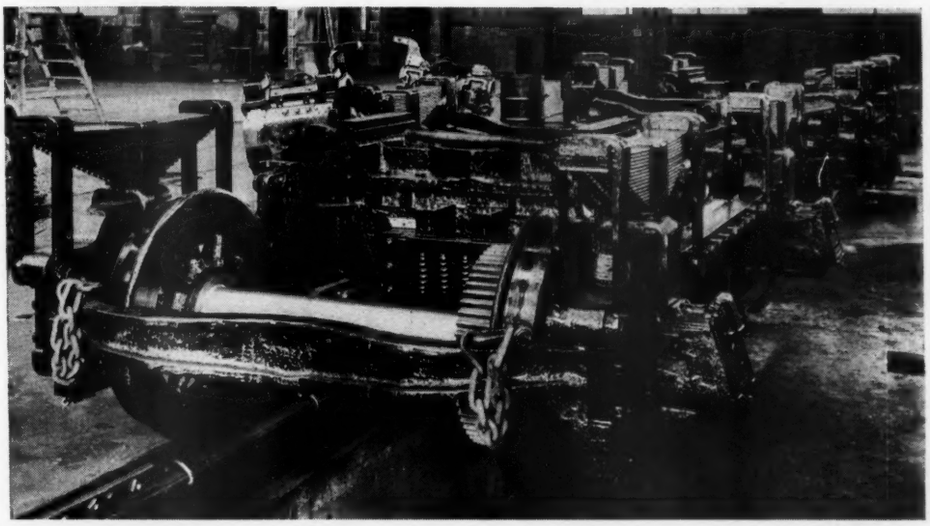
The radiator was manufactured by the Young Radiator Company and is of the finned-tube, sectional-core type. It consists of sections made from seamless copper tubes, five rows deep, having six fins per inch, brazed to header sheets, which in turn are brazed to header castings. The sections are bolted to water and oil rails, using Vellumoid gaskets at the joints. The radiator is mounted on the roof of the equipment hood, at an elevation which permits the water and oil sections to drain into a jacket water tank and a lubricating oil reservoir, respectively, when the engine is shut down, thus eliminating need for anti-freeze solution in the jacket water system during layover periods of the locomotive. The general arrangement of the radiating system insures cooling unaffected by locomotive speed, direction of operation or windage conditions. The air flow through the radiator is upward, and the rise in the temperature of the air passing through the core results in an appreciable amount of self ventilation, minimizing the operation of the blowers. Removable baffles are provided which may be hung in place during winter operation to restrict the self ventilating feature if required.

Air Brake Equipment

Westinghouse Air Brake Company's modified schedule 14 EL air brake equipment with quick application and release feature is used. A single-stage, two-cylinder, water-cooled air compressor, driven through a flexible coupling by a 115-volt, direct current, series motor, furnishes air for the operation at the brakes and electro-pneumatic control equipment. Both compressor and motor are equipped with ball bearings.

Cooling water for the air compressor is taken from the Diesel engine crank case jacket at the pressure existing therein, and conducted from the compressor to the engine radiating system. The compressor operates from the main generator during engine idling periods and from the auxiliary generator during periods when the main generator is furnishing power to the traction motors. This insures full speed operation of the compressor under practically all locomotive operating conditions.

The transfer of the compressor motor from the main generator to the auxiliary generator and vice versa is controlled automatically without attention from the operator. A compressor governor operates to cut off power to the compressor motor when full reservoir pressure is attained, eliminating losses in power incurred when the compressor is driven directly from the engine and unloaded.



The trucks are of special "three point suspension" design with eliptic springs over the journal boxes and cross equalization at one end

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TEN CENT PAY CHECK. Ed English, conductor on the Canadian National at Winnipeg, Man., still has an uncashed pay check which he received from the company when he first became a conductor in 1913. It is for 10 cents. In those days conductors had to buy their own uniforms; that is, they were supplied by the company but the cost was taken out of the conductor's first pay check. The sum of one dime was all that was coming to Conductor English on February 15, 1913, when the cost of his uniform was deducted.

Aerodynamics of the Railway Train

By Alexander Klemin*

Part II—Head-on air resistance for locomotives and trains—A survey of the wind-tunnel experiments which have already been made.

WE have seen that for a flat plate there is positive pressure at the front of the plate and negative pressure in the rear. From analogy with this distribution of pressure, it has been proposed that the total air resistance should be divided into (1) form resistance due to front positive pressure and rear suction, and (2) skin friction.

It is not practicable to make such a subdivision particularly for an unstreamlined train. Even for a streamlined train, it would be extremely difficult and involve a great deal of experimentation to separate the form drag from the skin friction. Particularly in the early stages of the art, it seems better to find total drag coefficients from wind-tunnel measurements.

For a long train a formula of the following character has been proposed:

$$K = K_0 + K_1 + K_2 \ldots\ldots\ldots + K_n$$

Where K_0 = coefficient of the locomotive, and K_1 K_2 $\ldots\ldots\ldots$ K_n = the coefficients of the n coaches.

A simpler formula is

$$K = K_0 + (n\text{-}1)\ K_1 + Kn$$

Where K_1 = the coefficient of a coach intermediate between the locomotive and the last coach.

A more satisfactory formula probably would be:

$$K = K_0 + K_1 + (n\text{-}2)\ K_2 + Kn$$

where K_1 = coefficient of first coach.
K_2 = coefficient of an intermediate coach.
Kn = coefficient of the last coach.

Such formulæ should be used with caution, particularly for short trains. In a short train the addition of another coach does not simply add the side or skin friction resistance but modifies appreciably the "fineness" of the train, that is, the ratio of length to width or breadth and so the whole character of the flow. In airship work resistances are investigated in relation to fineness ratio, but no simple formula of the above character has been developed. It is probably only for quite long trains that the last formula given above would be valid.

Wind Tunnel Tests of Single Rail Cars

1—New York University Test of a Conventional Rail Car and a Jaray Streamline Car.[1]

A single conventional railway carriage 35 in. long, 4.938 in. wide, 7⅛ in. high 1/23.6 scale with exposed wheels, smooth surfaces, and no ventilators, windows or projections represented, (see Fig. 1), when tested at 54.3 m.p.h., gave an engineer's coefficient of resistance of .00134 on the projected area of the car.

A Jaray streamline car (see Fig. 2) tested at the same speed, had a coefficient of .000591. These tests were made in the presence of a ground board, suspended just underneath the wheels of the car, but a velocity survey was made in the vicinity of the ground, and an average value of the velocity was employed in calculating the resistance coefficient.

2—Lay's Test on a Box with Rounded Corners and Exposed Wheels[2]

Lay's test on a box 25 in. long, 9 in. wide, and 8 in. high with wheels exposed, smooth surface and no projections (see Fig. 3) was made by the mirror method at speeds between 30 and 70 m.p.h. The average value of the coefficients K were as follows.

	K
a—Rectangular box, sharp corners and edges, with wheels.....	.00220
b—Rectangular box, sharp corners and edges, without wheels.....	.00219
c—Rectangular box, 6 in. radius, corners and edges with wheels...	.00151
d—Rectangular box, 6 in. radius corners and edges without wheels	.00146
e—Rectangular box, 9 in. radius, corners and edges with wheels....	.00118
f—Rectangular box, 9 in. radius, corners and edges without wheels	.00113

3—Tietjens Test of a Single Interurban Car[3]

The tests were made by the mirror method. Neither the size of the models nor speed of tunnel test are avail-

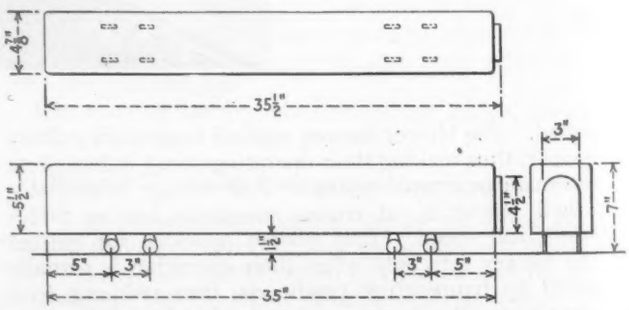

Fig. 1—Model of a conventional railway carriage as tested at New York University

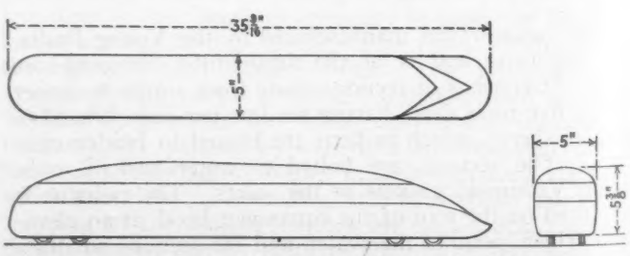

Fig. 2—Jaray streamlined car

* Professor in charge of the Daniel Guggenheim School of Aeronautics, New York University, New York.

[1] Unpublished report, permission secured to quote.

[2] Fifty Miles per Gallon with Correct Streamlining, W. E. Lay, S.A.E., January, 1933.

[3] O. G. Tietjens and K. C. Ripley, Air Resistance of High-Speed Trains and Interurban Cars, Transactions of the A.S.M.E. Applied Mechanics, September 30, 1932. See also *Railway Mechanical Engineer* for January, 1932, page 18.

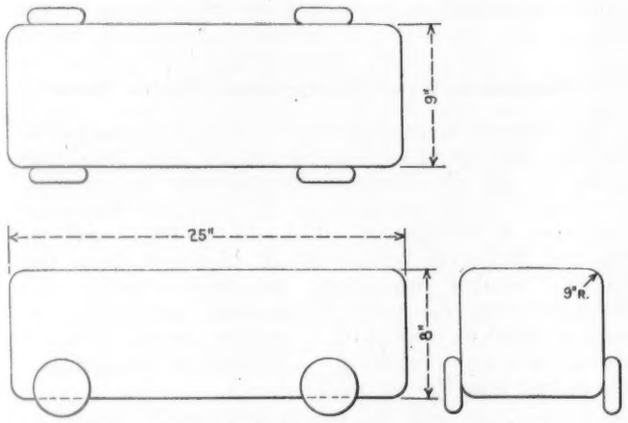

Fig. 3—Box with rounded corners and exposed wheels as tested at University of Michigan

able, although the scale is stated to be 1/25, with projected area of 83 sq. ft. for the full car and a weight of 25 tons. The models are shown in Fig. 4. The coefficients of resistance obtained in four tests were as follows:

	K
No. 1—Perfectly streamlined car	.000204
No. 2—Same as Car No. 1 but same in rear as in the front for two-way operation	.000306
No. 3—Same as No. 1 with streamlined front, rear and roof, but with windows and underparts of the present type car	.00046
No. 4—Present type car	.00127

The resistance of the "perfectly" streamlined car is noteworthy. From comparison of coefficients for Models No. 1 and No. 2 it is seen that the advantage of the narrow tapered tail is quite marked. The high value of Model No. 3 indicates the importance of flush windows and of enclosing wheels.

4—Leboucher's Tests on Some French Rail Cars[4]

The French Midi Railway was one of the first to decide to use light rail motor coaches, and carried out some interesting experiments in the wind tunnel at Issy-les-Moulineaux in November, 1931. See Fig. 5.

Model A constructed to a scale of $^{3}/_{100}$ consisted of two ends, front and rear, which are symmetrical and a central cylindrical portion divided into six equal and detachable sections. With the aid of the detachable

[4] Leboucher, Aerodynamical experiments on the exterior form to be given rail motor cars (Engineering Societies Library, New York City).

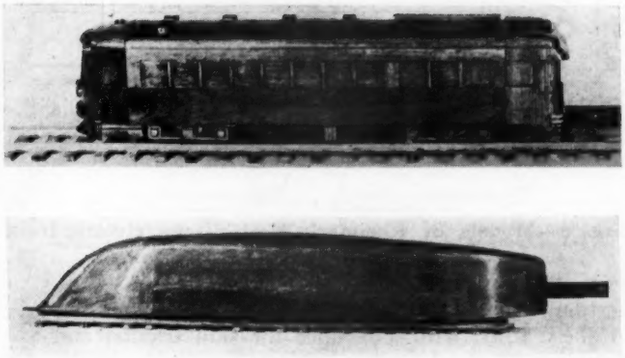

Fig. 4—Models of a present type and a streamlined interurban car

sections it was possible to reproduce rail coaches of different lengths varying from 43 ft. 4 in. to 76 ft. 1 in. The rail car was designed with a central raised driving compartment represented by a cup shaped projection with either a rectangular or elliptical base. It was found that the resistance of the central raised driving compartment was so large that its use was impracticable. The influence of length increase was found to be negligible. The value of K was approximately .00078.

Model B was tested by the mirror method. This model had symmetrical faired ends but the same width throughout its whole length. The value of K was .00088.

Model C was faired in plan form but not in elevation. The coefficient K was considerably less, namely .00039.

Model D had a rounded bow and a definitely "airship" form in plan. The lowest value of K for the series was obtained, namely .00028.

While the shape of these cars does not make them suitable for American practice, the results are interesting as they tend to show that fairing in plan, as well as in elevation, is helpful.

5—St. Louis Tests

Important tests were made on a type of car commonly used in electric railway service by the Electric Railway Test Commission at St. Louis in 1906. Dynamometer measurements were made of the pressure on the front

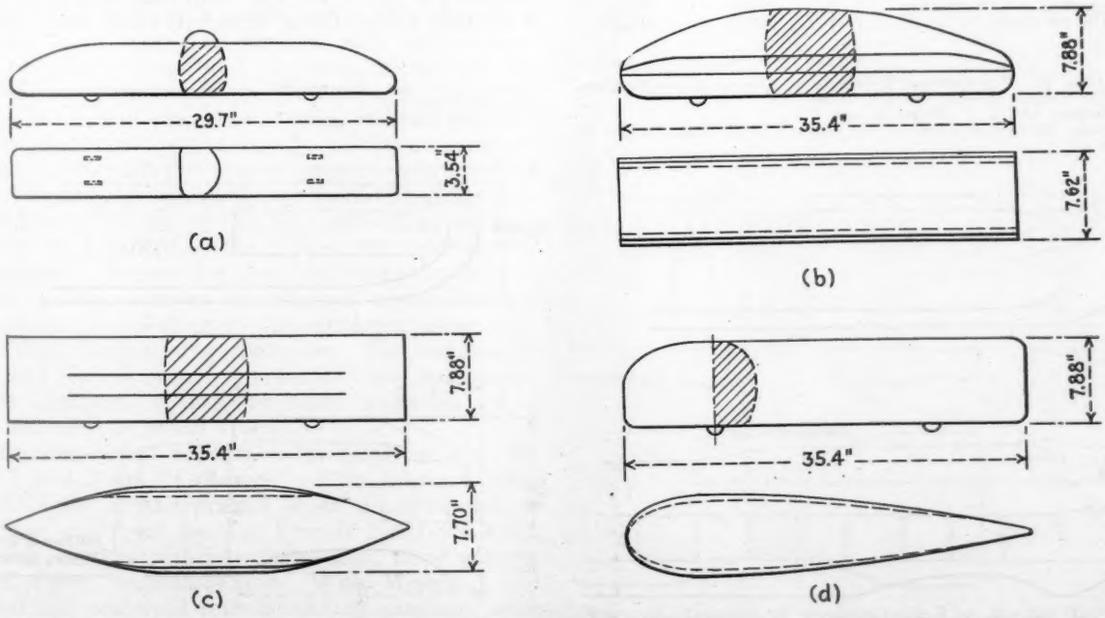

Fig. 5—Leboucher's models

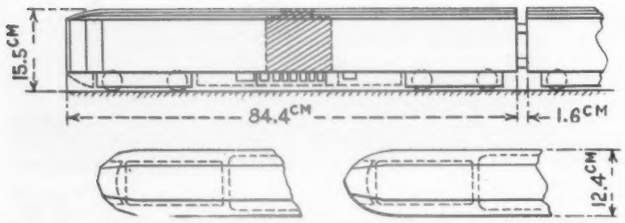

Fig. 6—Models of Rheinisch-Westfälische electric-train tests

vestibule and suction on rear vestibule. From analysis of these tests, with allowance for skin friction and assumption of equal pressure effects for trucks by W. G. Davis, Jr.[5], the following results are available on a basis of 60 m.p.h.

Shape of vestibule	Flat	Standard	Parabolic	Parabolic Wedge
Total pressure and suction (measured) resistance, lb.	835	535	263	245
Skin friction, lb.	47	47	47	47
Total resistance for car, lb.	882	582	310	292
Cross-sectional area of car alone, sq. ft.	72	72	72	72
K for car alone	.0034	.00225	.00120	.00113
Cross-sectional area of truck, sq. ft.	16	16	16	16
Resistance of truck (estimated), allowing 19 lb. for bottom of car, lb.	205	138	78	73.5
Total resistance of complete car, lb.	1087	673	341	318.5
Cross-sectional area car body and trucks, sq. ft.	88	88	88	88
K for complete car	.00340	.00212	.00108	.00101
K complete car, on car area alone	.00415	.00260	.00137	.00124

Westinghouse Tests on an Electric Train with a Small Number of Coaches[6]

Tests were made by the mirror method on a model of an electric locomotive alone and with one and two coaches for both an ordinary and a streamlined train.[7] The following table has been compiled from the curves in Tietjens and Ripley's papers in which a straight line extrapolation was made to trains of six coaches, because practically no difference could be detected in the air resistance of the first and second coaches in either of the train models. The projected area of the coaches is given as 126 sq. ft., and the resistance coefficients were apparently referred to this area.

	K Ordinary train	K Streamline train
Electric locomotive alone	.00204	.0009
Electric locomotive and one coach	.00306	.00128
Electric locomotive and two coaches	.00408	.00164
Addition to K per coach	.00102	.00038

[5] W. J. Davis, Jr. The Tractive Resistance of Electric Locomotives and Cars, General Electric Review, October, 1926.
[6] O. G. Tietjens and K. C. Ripley loc. cit.
[7] See *Railway Mechanical Engineer* for January, 1932, pages 18 and 19, Figs. 2 and 3.

The reduction in resistance by streamlining is very large.

Rheinisch-Westfälische Schnellbahn Tests

Experiments were made in the Göttingen wind tunnel[8] on two high speed electric coaches for the "Studiengesellschaft für die Rheinisch-Westfälische Schnellbahn." The models tested are shown in Fig. 6 where dimensions are given in centimeters. The scale of the models was 1/25 and they were built of wood. Such details as door handles, window projections, etc., were omitted. The front and rear car were of the same construction and were coupled together with a wooden dowel. The mirror method was employed. The cross-sectional area of the model was 160 sq. cm.

Description of Model	K
Model Ia—Without end cover or box enclosing accessories	.00128
Model Ib—With end cover and no box enclosing accessories	.00123
Model Ic—Without cover and with box enclosing accessories	.00110
Model Id—With end cover and box enclosing accessories	.00105

The two trains had an excellent coefficient of resistance to start with and the streamlining effects introduced were therefore slight.

The effect of submitting a round head for the sharp cornered head was found to be negligible, but the following experiments were of interest.

Description	K
Model Id	.00105
Model Id—With space between cars covered in	.00100
Model IId—Round head substituted for sharp-cornered head in front car	.00100
Model IId—With both cars equipped with rounded heads	.00128

Closing in the space between the two cars does not seem to affect the resistance very much; but providing both cars with rounded heads is seen to have quite a detrimental effect.

Tests of the Union Pacific Train

The tests were made at New York University[9] and the models employed are illustrated in Figs. 7 and 8. These models built by the Pullman Car & Manufacturing Company to a scale of 1/30 were of three-car trains. Train No. 1 consisted of a power car with an intermediate car and a tail car, with total length of 75 5/8 in. With this model three interchangeable cabs were sup-

[8] Ergebnisse der Aerodynamischen Versuchsanstalt zu Göttingen III Lieferung, page 161.
[9] Unpublished report, permission secured to quote.

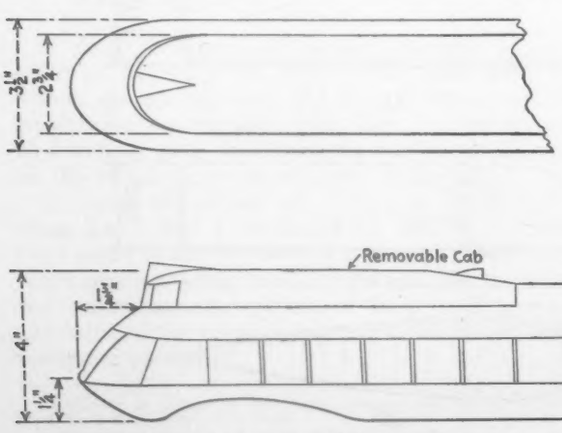

Fig. 7—The Union Pacific Train, Model No. 1

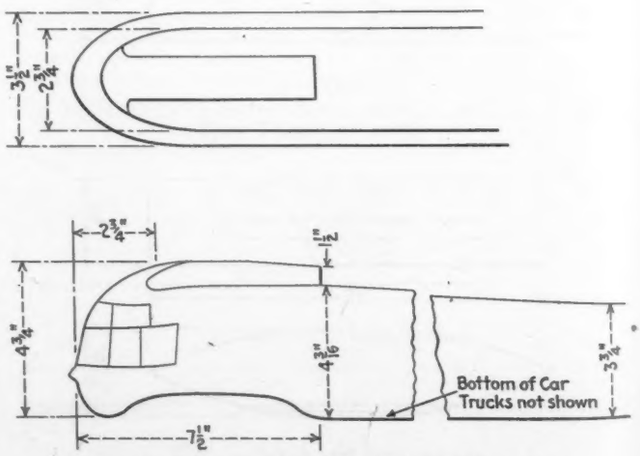

Fig. 8—The Union Pacific train, Model No. 2

plied. The cab with rounded nose, headlight and smoke top was designated as cab No. 1. The cab with headlight, nose consisting of five flat windows and a radiator on the top was designated as cab No. 2. The cab with rounded nose, no headlight and a radiator on the top was designated as cab No. 3. On top of all three cars of train No. 1 small projections representing ventilators were included. The tail car of this train tapered to a narrow section which was rounded at the extreme rear end. The nose car of train No. 1 was rounded in side view. From the rear end of the cab to the end of the front car the cross-section was constant.

Train No. 2 of a length of 74 in. consisted of a power car, an intermediate car and a tail car. In this model, no interchangeable parts were available. The nose of the power car was rounded in plan view, but quite blunt in side view. The cross-section of this car gradually tapered from a depth of $4\frac{3}{16}$ in. behind the cab to a depth of $3\frac{1}{4}$ in. at the rear of the car. The tops of the cars in this train were smooth, no ventilators being represented. The tail car had a tapering rear section but did not taper as sharply as train No. 1.

The cross-sectional area of the intermediate car was 11.5 sq. in. in both trains and all computations for the drag coefficient were referred to this area.

The coefficients obtained were as follows:

	K
Train No. 1, Cab. No. 1	.000887
Train No. 1, Cab. No. 2	.000963
Train No. 1, Cab. No. 3	.000887
Train No. 2	.001038

Train No. 1 had lower drag coefficients with all three different cabs. This is probably due to the better streamline shape of the nose and to the more highly tapered tail. Of the three cabs tested with train No. 1, cabs No. 1 and No. 3 show the same drag coefficient but cab No. 2 gives a higher value. Cab No. 1 appears cleaner aerodynamically as it had a smooth top, but the frontal area of No. 3 is less than that for No. 1. Evidently these two factors tended to counteract each other with the same drag values as a result.

Berlin Experiments on End Effects

Tests were made at the Berlin Technische Hochschule on end effects (front and rear). The models and suspension in the wind tunnel are shown in Fig. 9. The ground board method was employed. The models consisted of a single complete coach and two half coaches, connected so as to form a single block. Fixed ends *a* and *b* were held rigidly in position with metal cover plates *c* permitting the models to swing slightly on the balance without discontinuity of the entire set-up. The end pieces were so designed as to give the least possible excess of velocity above the velocity of the undisturbed air stream. Not all the excess velocity was avoided however. It may be surmised that there is a slight forward suction effect due to the air spaces at *c*, but this is more or less balanced by the greater resistance due to excess velocity. Hence the true side and skin friction resistance of the coaches is obtained approximately. The procedure is analogous to that employed in measuring the skin friction of a flat plate. By removal of the rear end piece *b* and of the rear half coach, information was obtained on the increased resistance of a coach when used as a tail coach.

The coaches tested are shown in detail in Fig. 10. Models 1 and 2 are "D-Wagen" of the German State Railroad, of the latest type and Model 3 corresponds to a new type employed by the French Nord Railroad. The models were smoothly constructed in wood without windows, doors, ventilators, etc. With Models 1 and 2, normal and oversized interconnecting corridors were employed to determine the resistance of the trucks, the

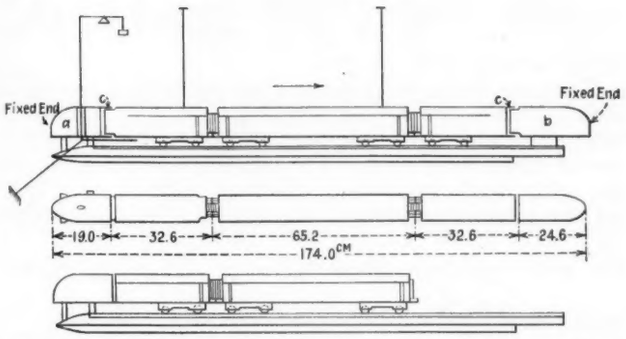

Fig. 9—Models and suspension for tests at the Berlin Technische Hochschule

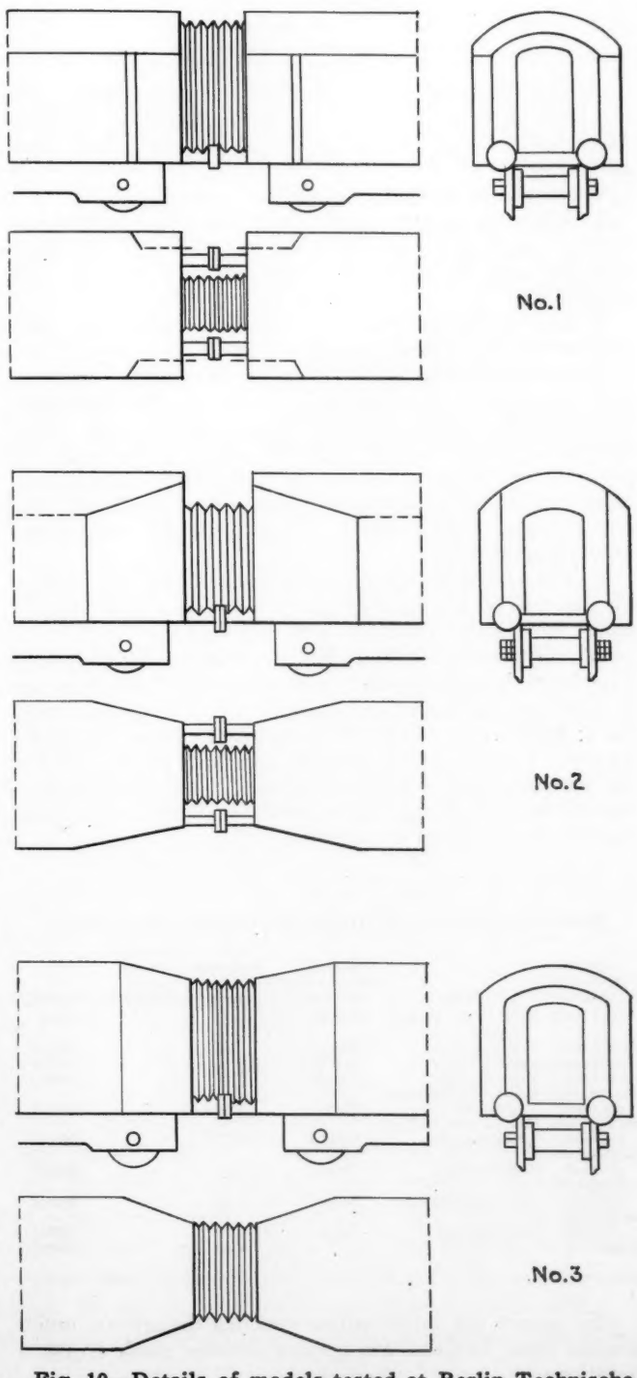

Fig. 10—Details of models tested at Berlin Technische Hochschule

coaches were also tested without running gear.

Such a test is not, of course, entirely valid from an aerodynamical point of view.

The tests were made at various wind speeds and a definite scale effect was observed. In the appended table of results, apparently the values obtained at highest tunnel speed were used. The equivalent areas given in this table need explanation. German writers very frequently refer resistances to an equivalent area on which the entire dynamic pressure, $\frac{\rho v^2}{2}$, is exerted; we must convert to our usual coefficient K as follows:

$$R = \frac{\rho\, v^2}{2} A_e = K\, V^2 A$$

$$\text{So that } K = \frac{\rho_{1.467^2}}{2} \times \frac{A_e}{A}$$

Where A_e = equivalent area in sq. ft.
A = actual projected area in sq. ft.

In the table such a conversion has been made. On the basis of data submitted by the staff of the *Railway Mechanical Engineer*, the projected area has been taken as 110 sq. ft.

From the table these conclusions may be drawn.

1. There is an appreciable difference in resistance—some 7 or 8 per cent between the "smooth" carriage and the one in which windows, ventilators, etc., are represented.

2. The truck resistance is a surprisingly large proportion of the whole resistance.

3. Comparatively small changes in design of coach ends may have an appreciable effect on the resistance. Thus Model 3 with the large intercommunicating corridor, and careful fairing into the corridor has only 69 per cent of the resistance of Model 1 with normal corridor. Without going to extreme departures from current practice quite worth while resistance reductions may be achieved.

4. The end effect is appreciable. Without the shelter of the tail piece, the increase in resistance of the last coach may be of the order of 50 per cent.

While Tietjens tested by the mirror method, and Vogelpohl by the ground board method (which is apt to give low values of resistance) yet Vogelpohl's tests check remarkably with full scale tests. Also Vogelpohl adopted a much more rational method of testing for the resistance of a single intermediate or end coach—though he would have done better to have had a locomotive shape at the front end.

Results of Tests at the Berlin Technische Hochschule

End or intermediate coach	Model	Type of interconnecting corridor	Equivalent area in sq. meters = F	Projected area in sq. ft., estimated	K = F(.00025)
As end coach	Model with windows, ventilators, etc.	Normal	2.44	110	.00061
As end coach	Model 1 smooth	Normal	2.28		.000578
As end coach	Model 2 smooth	Normal	2.15		.000540
As end coach	Model 3 smooth	Large	1.75		.000438
As intermediate coach	Model 1 with windows, ventilators, etc.	Large	1.88		.000470
As intermediate coach	Model 1 with windows, ventilators, etc.	Normal	1.73		.000433
As intermediate coach	Model 1 smooth	Normal	1.53		.000373
As intermediate coach	Model 2 or 3 smooth	Normal	1.69		.000423
As intermediate coach	Model 3 smooth	Large	1.20		.000301
Truck			0.58		.000145

His values for intermediate coaches though so much smaller than Tietjens' are a more reliable guide to computations.

Other experiments at the Berlin Technische Hochschule reported briefly in Z. V. D. I.[10] indicated that the resistance of an ordinary locomotive could be reduced by some 22 to 23.5 per cent by streamlining. The addition of a complete cover between coaches was found to be very beneficial. Smoothing out of windows, doors, gangplanks, etc., was found to be very helpful. A large tail piece on the rear car diminished the resistance of the entire train by 5 to 7 per cent.

[10] G. Wiens, Neuerungenim Personenwagenbanales Deutschen Reichsbahn, Z.V.D.I., April 1, 1933.

[*Part III will conclude the survey of existing wind-tunnel data and will interpret air resistance in terms of horsepower under various conditions.—Editor.*]

Worthington Type SA Feedwater Heater

THE Type SA locomotive feedwater heater equipment made by the Worthington Pump & Machinery Corporation, Harrison, N. J., is similar to the Type S, but differs from it in certain details, as all three essential parts have been redesigned and improved to secure added efficiency, dependability and economy. In these open-type heaters cold water from the tender is sprayed into the heating chamber where it contacts with exhaust steam from the locomotive cylinders. As the feedwater is heated, oxygen is driven off and escapes through the air vents to the atmosphere.

The equipment consists of three distinct units—the cold-water pump, the heater and the hot-water pump. These independent units are comparatively small and can be located to the best advantage for weight distribution, maintenance convenience, and appearance of the locomotive. The units are shown, diagrammatically arranged, in the illustration.

Cold water from the tender is supplied to the heater by a variable-speed turbine-driven low-pressure centrifugal pump located on the side of the frame near the tender. The steam turbine drives the pump at a speed necessary to deliver the amount of cold water required. The heater is set in the smokebox, either in front or back of the stack. Locomotive exhaust steam passes into the exhaust inlet at the bottom of the heater and through the exhaust check valves to the heating chamber, where it contacts with the cold water which has been forced through the spray valve by the cold-water pump. The heated water flows down through the hot-water outlet to the hot-water pump which delivers it to the boiler. The water level in the heater is controlled by a float-actuated control valve which regulates the speed and capacity of the cold water pump by varying the steam supply to the turbine. The hot-water pump is of the horizontal reciprocating type. It is located as close to the heater and the boiler check valve as practical.

The type SA equipment has a drifting control valve attached to the steam chest of the hot-water pump. This valve is operated by the pressure in the steam pipe or steam chest of the locomotive. When the locomotive throttle is closed or in the drifting position, this valve automatically reduces the quantity of steam for operating the pumps, thus limiting the amount of water fed to the boiler. The pumps will automatically speed up again when the locomotive throttle is opened. The drifting control valve relieves the engineman of the necessity of closing the pump-operating valve when drifting or making short stops.

The Type SA equipment is furnished in three sizes having capacities of handling 6,600, 9,000 or 12,000 gallons of water per hour.

Putting "Pep" in The Organization

An Employees Magazine Editor, in a chat with the Editor, emphasizes the importance of the Mechanical Department in developing a strong family spirit

IT is difficult to sum up in a short paragraph the various reasons advanced for the establishment of railway employee magazines. One group will emphasize the importance of developing a strong family spirit within the organization so that each department will co-operate more intelligently and enthusiastically with the others in promoting the interests of the railroad as a whole. Others will emphasize the importance of inspiring and encouraging the employees to use their influence in securing freight and passenger business for the railroad—in other words, to stimulate the activities of booster clubs or similar movements. Certainly it is no easy task to induce an enthusiastic spirit of teamwork in a large organization, thinly spread over a great area.

Recent years have been difficult ones for employees magazines in industries and organizations generally, as well as on the railroads. Many of these publications have been wiped out of existence; others have been greatly reduced in size. That they have survived at all is a tribute to the value placed upon them by the managements. As business has picked up, some of the discontinued magazines have been revived, and those which have continued publication have been enlarged and strengthened.

About 25 per cent of the employees of a railroad are included in the mechanical department. Congregated in considerable numbers at important repair shops and engine terminals, they can be a most important factor in representing the railroad in the local communities, both in assisting to interpret its problems to the public and in soliciting business and support. The railway employees' magazine, properly edited and distributed, can do much to educate and inspire the employees to use their best efforts in these directions.

There are, of course, considerable differences of opinion among the editors of employees' magazines as to the kinds of articles that should be used, and this is particularly true in times such as these when most of the publications are forced to operate on minimum budgets. Much stress is placed on the intimate personal notes and local news items from correspondents at important points. Most of these magazines include articles concerned with the relations between the railroad and the public, as well as interesting information about points of special interest on the railroad. Some of the magazines play

*Fourteenth of a series of interviews with men outside the mechanical department, commenting in a constructive way upon the possibilities of that department.

up records of all sorts in the effort to stimulate a friendly competitive spirit throughout the organization. Occasionally excellent articles will be found, giving information about new and unique equipment and facilities.

How Mechanical Department Can Co-operate

With these facts as a background, I approached the editor of one of the railroad employees' magazines with this question: "How can the mechanical department co-operate with you in your efforts to strengthen the magazine and make it of greater interest to the employees as a whole?"

"First," replied the Editor, "let me say that we receive splendid co-operation from our correspondents generally, and particularly from those at shop points, who usually come through with excellent material about the personnel and local happenings.

"Our great difficulty," he continued, "is to get well-illustrated news items and articles about important improvements in equipment and facilities, and of unusually good records either in the operation of the equipment on the road, or concerned with the output of the repair shops and engine terminals."

"Do you really find," I asked, "that your readers in other departments are interested in mechanical details, such as might be included in the sort of articles you mention?"

"Yes," replied the Employees Magazine Editor. "In the first place, you must remember that about 25 per cent of the railroad employees are in the mechanical department. Many of those in other departments, however, have to do with the operation and use of the equipment and they are greatly interested in knowing what sort of improvements are being made and how they will be reflected in improving the service, or in making it possible to operate with greater efficiency and economy."

Cites a Specific Instance

"Can you give me an illustration to support this statement?"

"Yes," replied the Employees' Magazine Editor. "Recently we incorporated an improvement which was most noticeable in the exterior appearance of the locomotives which draw our crack passenger trains. We received several inquiries as to the purpose and intent of this device. We would have made a real hit with these people, and many others, as well, if we had been tipped off in advance and had been able to make a suitable announcement in the columns of our publication.

"Another illustration of the failure of the mechanical department to co-operate with the editor of the Magazine occurred recently. My attention had been directed to two new developments in motive power, each of them promising something interesting and perhaps significant. My informant was not even a railroad man, but a passenger interested in things mechanical. I immediately instituted inquiry with the mechanical department about both developments and got the customary answer—that both were experiments and that in due time we would be advised concerning how they were working out. Imagine my surprise a couple of months later to be sent two clippings from my passenger friend. Both were from a recent issue of an English railroad magazine, and covered the two experiments in detail."

"Is this due to indifference on the part of the mechanical department officials," I queried, "or is there some special reason for lack of co-operation?"

Lack of "News Sense"

"In the first place," replied the Editor, "our mechanical department friends apparently fail to realize how much the employees of the mechanical department and others, as well, are interested in information of this sort. They do not recognize the extent to which it stimulates pride in the road because of its accomplishments and its progressiveness. Frankly, I suppose we can ascribe it to a lack of 'news sense' on the part of these officers.

"Sometimes I know," he continued, "that the unwillingness of mechanical department officers to release information about new developments is because they, too, are under wraps. In other words, they have been told by the management to keep quiet about what they are doing, and they have no alternative. In cases like this I have sometimes received my first information about new developments from shopmen whom I have met about town, or on a trolley car. And, then, of course, the new developments are no longer a secret, even if the editor can say nothing about them in his Magazine."

"Are you doing your part to assist in developing a 'news sense' in the mechanical department?" I asked. "Isn't it asking a little too much to expect officers busy with technical affairs to keep this matter foremost in their minds?"

"Apparently we have failed badly in this," replied the Editor, "but we do take every possible opportunity to interest these officers in the kind of material that we would like, and naturally we go directly to them if we get tips about new developments. With our limited staff and facilities, however, it is quite impossible for us to keep up with these improvements and we are sorely in need of more real help and co-operation."

"Is it not true," I asked, "that in some instances it may not be advisable to mention improvements which are being made in the nature of trials or tests?"

"Possibly that is true," replied the Editor, "but looking back over the years, I think I can say with some emphasis that there has been too much conservatism in that respect. As I see it, for instance, the new high-speed, streamlined trains are in the nature of an experiment. Whether they succeed in their present form or not, the very fact that they have been built and placed in operation has attracted widespread favorable attention in this country and throughout the world. The public is impressed with the fact that the railroads are alive and progressive, and that they are willing to take the initiative in trying out new ideas which may help to strengthen them and regain business which has been lost to other types of carriers. I heard an officer of one of these railroads say the other day that they had already secured so much favorable publicity from one of these trains that they could afford to throw it into the ocean and forget about it, if it did not make good to the degree that they had anticipated.

Give Employees Something to Talk About

"It seems to me," continued the Editor, "that you can apply the same principle to articles concerning new devices or new methods and practices which may be published in the employees' magazines. Give the employees something to think and talk about! It will indicate a spirit of progressiveness and virility on the part of the railroad and in many instances will inspire the employees to boost the road in talking with their friends and neighbors."

"You appear to feel rather strongly on this subject," I ventured. "Have I touched a sore spot?"

"Yes, and no," replied the Editor. "I was a bit chagrined the other day when I saw a story in the newspapers about certain new developments in our passenger

equipment that we knew nothing about. In other words, the newspapers 'scooped' our magazine, although the nature of the improvement was such that it is of special interest to our employees. Moreover, it is something that they can use to excellent advantage as a talking point in their efforts to build up good-will for the railroad, with a view to securing business."

"What other kind of articles can the mechanical department give you that will be of special value in assisting you to stimulate a greater interest on the part of the employees?"

"A lot of good records are being made in different departments, or at different points on the road, which would be a real inspiration to our employees, and in many instances would stimulate a healthy and friendly competition on their part. It may be asking too much to expect that these matters will automatically be sent to our office. They do, however, mean so much to the welfare of the railroad as a whole that I wish someone in every department and at every important point on the railroad could be definitely assigned the task of sending such material to us. I have about come to the conclusion that we cannot expect the right sort of co-operation except from people who have some 'news sense' about the value of these particular things, and who will have that 'news sense' stimulated by the fact that the task of getting certain material to us has been quite definitely assigned to them. I am thinking now not of our regular correspondents, but rather of staff specialists who can co-operate with us."

"Is there any question of responsibility or censorship involved?" I asked.

"Yes," replied the Editor. "Which leads me to say that I do wish these men could also be given sufficient authority so that the material would not have to be routed around over several desks before it reaches us. I realize the necessity, of course, of having someone in authority check over the advisability of our publishing material of this sort. It is surprising, however, how many good things have been buried in this process, or if they have finally wiggled through, have been so delayed that the news value was largely lost. If they could realize how much these things can be used to stimulate and inspire the organization as a whole, I feel quite sure that some of our officers would be less conservative in their attitudes, knowing full well that the road in most cases stood a chance of gaining far more than it could possibly lose by a more liberal policy on their part.

Brake and Draft-Gear Action During Emergency Applications

By O. R. Wikander*

Simple formulae for relationship between travel and capacity of draft gears, car length and mass, and speed of propagation of air-brake emergency applications are derived from a mathematical analysis of the wave action in long freight trains

WHILE it has been recognized that a certain interdependence exists between air brake and draft gear action the nature of this relationship has remained rather obscure. In an effort to throw some light on this subject the mechanical processes involved have been analyzed for certain ideal conditions and the results obtained have led to the formulation of a few simple rules governing said relationship. Omitting the mathematical analysis, the main rules will be given which have been derived therefrom and these rules will be checked by such test results as are available.

Coupler Pressures and Tensions

The object of emergency braking is to stop the train in the shortest possible distance. For this reason the air brakes should be applied as quickly and effectively as possible and the draft gears should be strong enough to cushion the resulting car impacts without going solid.

The application of the brakes begins at the front end of the train and proceeds with short intervals from car to car, under the influence of reduction in brake pipe pressure, throughout the train. The speed of brake application should, of course, be as high as possible in order to obtain a quick stop. The progressive brake applications generate coupler pressures between adjacent cars beginning at the front end where a coupler pressure is created between the first and the second car and, progressing throughout the train, a higher pressure is created between the second and the third car, a still higher one between the third and the fourth car, etc., until this pressure reaches a maximum value somewhere in the rear part of the train. From there on the coupler pressure decreases either gradually and uniformly, or rather abruptly towards the end of the train, depending on the characteristics of the brake equipment and on those of the draft gears.

During the formation of these coupler pressures the car speeds become equalized and all cars in the train attain a certain uniform speed at the time said coupler pressures reach their maximum values. These coupler pressures tend to accelerate the front end and retard the rear end of the train, creating a higher speed at the front than at the rear end. This difference in car speed will stretch the train and will gradually change the coupler pressures to coupler tensions. Said tensions appear at first at the rear end of the train between the last and the second last car, then between the second and third last car, the tension at that point being higher than that between the last and second last car. The tension between the third and fourth last car is higher still, and so on until the maximum coupler tension is created at some point towards the front end of the train in the same way as the

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maximum pressure was created somewhere towards the rear end. The coupler tensions thus created are much smaller than the coupler pressures which created them due to the dampening effect of the energy absorption in draft gears, car bodies and lading.

The period of coupler tensions is followed by a second period of coupler pressures which, however, as a rule are very feeble and thus of negligible influence on the action of the train. It is thus seen that the progressive brake application creates a pressure wave which, periodically changing into a tension wave, passes back and forth through the whole length of the train until completely dampened by the energy absorption in the draft gears, the car bodies and the lading. If, and as long as, the draft gears yieldingly resist this wave without going solid the created coupler pressures and tensions will be kept within moderate limits and will not cause any serious damage to the equipment. If on the other hand the draft gears are not strong enough to withstand the pressures created by the said wave, they will be closed solid by the first pressure wave and the otherwise moderate pressures will rise to destructive values and may cause telescoping of the cars and derailment of the train.

It is thus important that the characteristics of the draft gears be adapted to the intensity of the brake action so as not to go solid. A mathematical analysis indicates that the greatest coupler pressure, which can be created at any point in the train under any conditions of car loading, draft gear and air brake characteristics, provided that the draft gears do not go solid can be computed as follows:

Let:
F = maximum retarding force in pounds per car during emergency brake application.
n = number of cars in train.
P = maximum possibly occurring coupler pressure in pounds.
q = draft gear travel in feet.
C = minimum required draft gear capacity in foot-pounds.

The minimum capacity of a draft gear which will permit emergency braking of a train under all speed and load conditions without closing any one of the gears is determined by the formula

$$C = \frac{Fnq}{4} \quad \ldots\ldots (1)$$

The maximum possibly occurring coupler pressure is the reaction of the gear when subjected to an impact of the same magnitude as the capacity C.

If the characteristics of the draft gear are such that it compresses from zero to its maximum travel in proportion to the applied pressure, the maximum occurring coupler pressure will not exceed the value

$$P = \frac{2C}{q} \quad \ldots\ldots (2)$$

or, inserting the value of C from equation (1) in equation (2) the maximum coupler pressure would, under the stated conditions be:

$$P = \frac{Fn}{2} \quad \ldots\ldots (3)$$

The formula (1) expresses the fundamental rule for the relationship between draft gear capacity and braking force and can be worded as follows:

In order positively to prevent the draft gears from going solid during a brake application under all load and speed conditions, *the capacity of the draft gear should be equal to or larger than 25 per cent of the product of the maximum retarding force per car, times the number of cars in the train, times the travel of the gear.*

If this condition is not met, there is always danger that, for certain load and speed conditions, the draft gears will go solid during braking and destructive forces may develop during the first pressure wave and even during the tension wave which follows it. If, on the other hand, the above condition is met, the compression forces will always be moderate and, if draft gears of a fair amount of absorption are used, the tension forces which follow them will not be destructive to equipment and lading.

Car Retardations

The retardation to which a car is subjected during emergency brake application depends on its mass and its retarding force. The latter depends on the braking force acting on the car as well as on the difference between the two coupler forces acting on it. This difference is largest if the characteristics of the draft gears and air brakes are such that the maximum coupler pressure abruptly drops from its maximum value to zero, in which case this total pressure, in addition to the braking force, acts as the retarding force on the mass of one car.

The operating conditions, under which such a sudden drop in coupler pressure occurs are defined by the following relationships.

Let
L = length of one car, from coupler to coupler in feet.
v_1 = speed of air brake propagation in feet per second.
M_1 = critical mass of car or the mass which will cause an abrupt drop of the maximum coupler pressure.
a = maximum car retardation in feet per second per second.

Such sudden drop of coupler pressure occurs if and when:

$$M_1\, q^2\, v_1^2 = L^2\, C \text{ or}$$

$$M_1 = \frac{L^2\, C}{q^2\, v_1^2} \quad \ldots\ldots (4)$$

and the corresponding maximum car retardation is

$$a = \frac{P + F}{M_1} \quad \ldots\ldots (5)$$

or if the characteristics of the draft gears are such that the value of P from formula (3) can be applied, it is

$$a = \frac{F\,(n+2)}{2M_1} \quad \ldots\ldots (6)$$

It will be seen from formula (6) that the value *a* decreases with increasing values of M_1 and, in order to obtain a low retardation, the mass of the car, for which this abrupt drop of coupler pressure occurs should be as great as possible, preferably greater than that of the fully loaded car so as to completely avoid this undesirable condition.

Referring to equation (4) it will be seen that only *q* and *C* are dependent on the draft-gear characteristics and that the mass M_1 increases with increasing values of *C* and with decreasing values of *q*. High draft gear capacity and short travel are thus desirable in order to decrease the maximum car retardations.

Use of Above Method for Analysis of Draft Gear and Brake Action

If the maximum retarding force per car is known, the above formulae make it possible to compute the minimum draft gear capacity, which for a given gear travel and number of cars will permit safe emergency braking.

If the thus computed draft gear capacity is not available the retarding force must be temporarily reduced to such an extent that it can be applied without causing the gears to go solid and thus avoid dangerous or even destructive coupler pressures. Such a reduction in the available maximum retarding force is, of course, undesirable as it increases the minimum stopping distance of

the train and thus endangers its safety of operation.

According to the A.R.A. 1933 Specifications for Freight Brakes, Circular D.V.-803, page 11, a nominal initial brake cylinder pressure of 15 lb. is to be developed in not more than 1½ seconds and the maximum pressure in nominally 10 seconds. This delay in the application of the maximum air pressure increases the minimum stopping distance of a long train about 300 ft. and could be avoided if the draft gears were of adequate capacity, as computed from the above formulae.

In order to illustrate the application and check the validity of the above formulae a few examples will be selected from published official brake tests.

Example No. 1

A.R.A. Brake Test, Siskiyou Line, Southern Pacific. Test tank cars of the following specifications were used:

Weight of empty car.....40,000 lb.
mass M 1244
Weight of loaded car.....120,000 lb.
mass M 3732
Length of car L.....37 ft.
Draft gear capacity (including elastic action of one-half car body under the closing pressure of the gear) C=.....18,000 ft.-lb
Travel of gear q plus give of one-half car body under the closing pressure of the gear.....273 ft.
Retarding force per car in lb. F=.....6000

Test No. 12202 (Series No. 101, Trial P3)
$n = 100$ empty cars
$v_1 = 600$ ft. per sec.

The minimum required draft gear capacity, computed from formula (1) would be

$$C = \frac{Fnq}{4} = \frac{6000 \times 100 \times .273}{4} = 41{,}000 \text{ ft.-lb.}$$

The actual draft gear capacity is only 18,000 ft.-lb. and thus entirely inadequate. This explains the results of the attempt to make an emergency stop from a speed of 12 m.p.h. about which the official report states that "the rear end of car No. 97 was raised off the trucks and telescoped the head end of car No. 98."

If the capacity of the draft gears had been adequate and their characteristics such that formula (3) would apply, the greatest possible coupler pressure would not have exceeded

$$P = \frac{Fn}{2} = \frac{6000 \times 100}{2} = 300{,}000 \text{ lb.}$$

which would have been entirely harmless.

The critical mass M_1 which would cause an abrupt drop of coupler pressure can be computed from formula (4).

Since this formula does not apply if the draft gears go solid C must be at least = 41,000 ft.-lb.

Assuming this capacity it is

$$M_1 = \frac{L^2 C}{q^2 v_1^2} = \frac{37^2 \times 41{,}000}{.273^2 \times 600^2} = 2100$$

The corresponding car weight is

$$2100 \times 32.2 = 67{,}500 \text{ lb.}$$

This is the intermediate load at which the maximum car retardation will occur. Computed from formula (6) it is

$$a = \frac{F(n+2)}{2M_1} = \frac{6000(100+2)}{2 \times 2100} = 146 \text{ ft./sec./sec.}$$

This is the maximum car retardation which possibly could occur in such a train if the draft gears were powerful enough so as not to go solid.

This high retardation occurs only if the mass of the car rather closely corresponds to the critical value M_1 and drops quickly to moderate values as soon as the car mass differs from said value. Furthermore, the above maximum retardation is fully attained only if the force closure diagram of the draft gear is a straight line, with the reaction proportional to the gear travel.

It is, nevertheless, desirable to select the draft gear characteristics so that the critical mass of the car falls above its usual loading range and thus keep the car retardations as low as possible. Really destructive car retardations occur, however, as a rule only if and when the draft gears go solid.

Example No. 2

It is desired to know how much retarding force can be applied per car in a 150-car train without closing the average draft gear or, in other words, to what extent must the initial braking force be reduced in such a train in order to avoid the closing of draft gears, which just meet the A.R.A. minimum requirements for certified gears.

Solving the above equation (1) for F it is

$$F = \frac{4C}{nq} \text{ in which}$$

$C = 18{,}000$ ft.-lb. for new gears and as low as 15,000 for used gears
$n = 150$
$q = 2\frac{1}{2}$ to $2\frac{3}{4}'' = .208$ to $.229$ ft.

Using the low value of C and the high value of q the highest safe retarding force F is

$$F = \frac{4 \times 15{,}000}{150 \times .229} = 1750 \text{ lb.}$$

Assuming that the light car weighs 40,000 lb., that the full emergency air pressure would produce a brake pressure of 60 per cent of the weight of same or

$$.60 \times 40{,}000 = 24{,}000 \text{ lb.}$$

and that the coefficient of friction were as high as 25 per cent. The maximum retarding force would then be

$$24{,}000 \times .25 = 6000 \text{ lb.}$$

Since only 1750 lb. is safe to use, the full air pressure of about 60 lb. per sq. in. should be reduced to

$$60 \text{ lb.} \times \frac{1750}{6000} = 17.5 \text{ lb. per sq. in.}$$

which is about the figure arrived at in the A.R.A. official brake tests.

The above A.R.A. Freight Car Specifications prescribe an initial air pressure of 15 lb. which is gradually increased for 8½ sec. before the full air pressure is applied.

Example No. 3

Emergency braking of the above train with 150 cars fully loaded, using standard type K equipment, gear travel same as in Example No. 1.

(A.R.A. Brake Tests No. 11201, 11202 and 11204 on table No. 188)

The great buffs indicate that the gears go solid.

According to formula (1) the minimum safe draft gear capacity for such a train at the above gear travel and under all load and speed conditions would be

$$C = \frac{Fnq}{4} = \frac{6000 \times 150 \times .273}{4} = 61{,}400 \text{ ft.-lb.}$$

which proves the inadequacy of any commercial gear for this service.

If a gear of the above capacity were used the critical car mass could be computed from formula (4)

$$M_1 = \frac{L^2 C}{q^2 v_1^2} = \frac{37^2 \times 61{,}400}{.273^2 \times 600^2} = 3130$$

(*Continued on page 327*)

Tests of Box-Car Designs Made by A. R. A.

The Car Construction Committee investigates stresses in box-car structures of three designs by extensometers and deflectometers. Upon completion of this investigation the loaded cars were subjected to impact tests at speeds up to 18 m. p. h.

AN important and extensive research of the stresses and deflections imposed by static and dynamic loads on all important detail members of box cars of three designs has been completed by the Car Construction Committee and a report with numerous charts has been submitted to the Mechanical Division. No similar experimental research of such completeness has ever been attempted.

After completion of the stress tests the cars were subjected to severe impact tests to determine the effect of collision blows on sills and other structural members. The fundamental objective in this portion of the tests was the determination of the ability of box cars of the new A.R.A. standard design to withstand abnormally severe punishment resulting from collisions at speeds well beyond those to which the various kinds of lading ordinarily transported in such cars could be expected to escape severe damage or destruction. A further object was a comparison of the performance of this design with other earlier significant designs typical of modern box-car construction.

Car Designs Tested

The following box cars of three well-known designs were selected for test:

(*1*) *A.R.A. Standard Design.*—This is a steel-sheathed wood-lined box car of 50 tons nominal capacity submitted in 1932 and illustrated and described in A.R.A. Circular DV-768.* Five of these cars were completed in September, 1933. Their light weight was about 44,000 lb.

The program under which this car was created had as its object the production of a design representing the latest state of the art in reference to weight, cost, construction, strength, distribution and utilization of materials employed, general utility and dependability for general interchange service, so that when completed the car would be too attractive for railroads to disregard and would be of such character that any road might adopt it as standard and construct thereto its future equipment of this type.

Approximately 3,500 lb. of weight were saved in the car body as compared with existing constructions of equivalent size, capacity and type. No alloy steels or integrally welded constructions were used except for the welded center-sill seam, but the belief was expressed that in the not far distant future both these deviations from present general construction practice might be expected to provide further practical means of reducing weight. During the past year or two steel manufacturers, through requests from and co-operation with certain car builders and manufacturers, have made definite progress which apparently is about to result in quantity production at non-prohibitive prices of certain alloy steels having improved properties suitable for use in the construction of still lighter freight cars. This subject is now receiving active study with a view to early constructive action if found practicable.

(*2*) *Tentative A.R.A. Design.*—This was first submitted in 1923, being illustrated and described in A.R.A. circular DV-286.† The car used for the stress tests was Pennsylvania No. 52748, built in October, 1929, according to these drawings. The cars used for the impact tests were Pennsylvania Nos. 100297 and 100289, built in April, 1933. Their light weight was approximately 47,000 lb.

(*3*) *U.S.R.A. Design.*—This was produced in 1919 and a considerable number of cars were constructed for a number of roads. The car used for the stress test was New York Central No. S-93095, built in 1929. The cars used for the impact tests were (N. Y. C.) Nos. S-93413 and S-93087. Their light weight was 47,600 lb.

Reasons for and Objects of the Tests

Five sample A.R.A. standard cars having been completed in September, 1933, it became highly desirable to ascertain the extent to which the objectives of the design had been attained; also, to make comparisons with the two significant earlier designs previously tested as a check.

Investigation by means of extensometers and deflec-

*See the Railway Mechanical Engineer, August, 1932, page 317 for description and drawings.

†See the Railway Mechanical Engineer, July, 1925, page 426, for description and drawings.

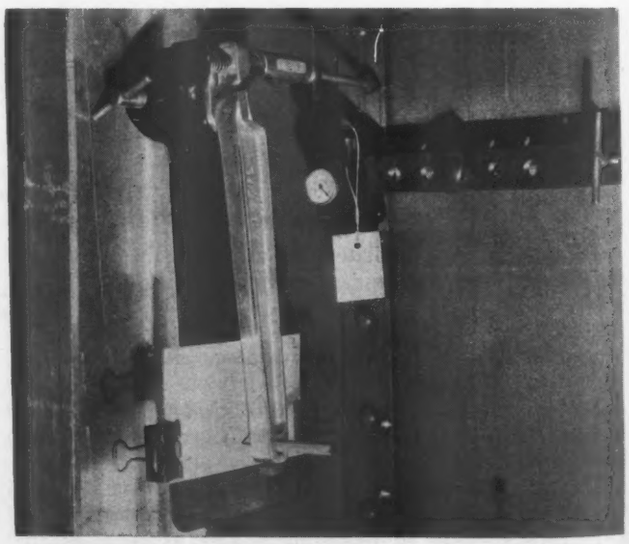


Fig. 1—Extensometer (right) and deflectometer (left) mounted on the car body

tometers of strength and deflection characteristics present in various forms of structures is not new, but this method of testing previously had not been utilized for complete car structures. About two years before the Pullman Car & Manufacturing Corporation had developed the technique and instruments required to a point where its engineering department was in position to conduct actual research by this method.

The first specific object was to check the new design and to obtain information for use later in the advancement of the art from the records thus made available of the stresses and deflections in all stress members of the car body under static and dynamic (live) load conditions. The latter were intended to approximate the effects of movements at high speeds over average trackage and road bed. A further specific object was to make direct comparison with the two earlier significant designs of steel-sheathed, wood-lined box cars.

Method of Conducting Stress Tests

The extensometer used was made by the Tinius Olsen Company and is the smaller of two instruments equipped with a dial shown in Fig. 1. In the instrument itself one leg is fixed and the other is movable, both pointers being set in accurately formed conical holes provided for the purpose. Stretch or compression in a 2-in. flat surface of the metal to which it is attached is indicated on the dial and may be identified either as tension or compression through the direction of rotation of the pointer.

The instruments are held to the car structure by means of brackets in such position that the two spacing members are free to move in either direction, and the movement of the sheet is indicated on the dial so long as the stretch is below the yield point. The amount of movement is very slight and is a function of the modulus of elasticity of the material. Each dial graduation corresponds to a nominal stress of 1,000 lb. per sq. in.

The deflectometer, the larger instrument shown at the left in Fig. 1, was developed and built by Pullman. In effect, the deflectometer is a bell crank with dampened movement, the ratio of actual deflection magnification being about 8 to 1.

Naturally, the deflectometer must be mounted on and rigidly clamped to a framework supported independently from the portions of the structure in which deflections are to be measured. This was accomplished by using the construction at the ends of the body bolsters as supporting points for the framework, which consisted of aluminum rolled channel sections and diagonal brace rods. Photographs, Figs. 2, 3 and 4, clearly illustrate the framework arrangement and application.

After mounting each instrument the pencil is brought into contact with the recording chart and a datum line is drawn before lading is applied. Deflection under static load is recorded on one side and under dynamic (live) load on both sides of the datum line. Only maximum readings are used, as the corresponding maximum deflections only are of interest.

Under static load conditions the supporting framework does not introduce any element of error, but under live load the inertia and deflection of this framework must carefully be accounted for. Consequently, tests are first made of the supporting framework only so as to determine the deflections caused by the dynamic (live) weight of the framework alone. The live-load readings for the car structure are then corrected accordingly. During the tests both deflectometers and extensometers are mounted so as to obtain readings at practically identical points throughout the structure under investigation.

All essential stress members or members which might be subjected to stresses of consequence—center sills, body bolsters, cross-bearers, end sills, roof carlines, side plates and sills, also door and side posts—were investigated for all three significant designs by taking readings at various points in these members and it was the effort under all conditions ultimately to obtain the effects of the maximum permissible loading within the car and this was worked up by progressive steps as follows.

The light-weight of the car was first obtained and the difference between this and the total permissible weight on the rail, 169,000 lb., was taken as the maximum lading to be placed in the car. The loads were uniformly distributed over the floor in the form of bags

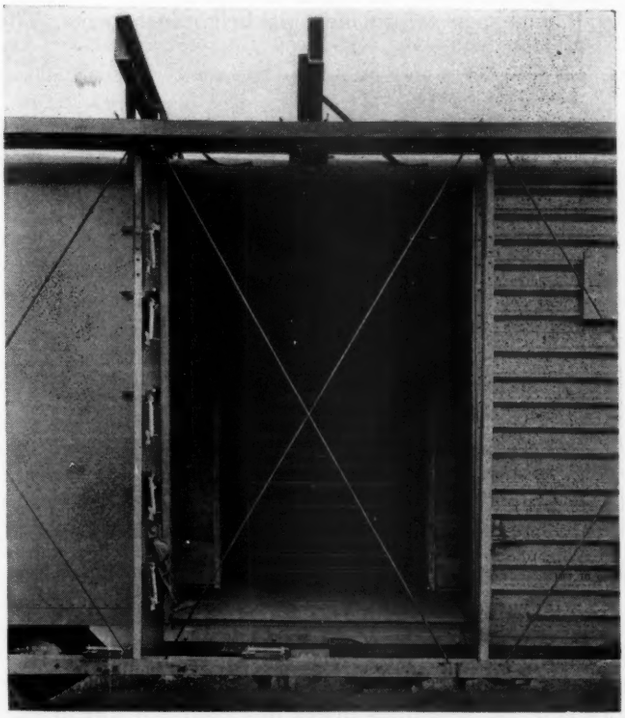


Fig. 2—Framework and instruments for testing door side posts

of sand each weighing 100 lb., together with bags of sawdust weighing somewhat less in order to increase the depth of the lading and were applied in progressive steps—one-fourth, one-half, three-quarters and full load. At full load the depth of the lading ranged from 3 ft. 7 in. to 3 ft. 8½ in. Readings were taken under each condition and from the records static line curves were plotted for deflection and stress readings.

Under dynamic or live-load conditions accurate readings cannot be obtained with the extensometer as it is an indicating device and, consequently, its inertia renders readings unsatisfactory. This does not apply to the deflectometer, as accurate readings therewith can be recorded under dynamic loads and these represent positively the deflections which are in strict proportion to the stresses occurring in the structure up to approximately the yield point of the material; therefore, the deflectometer was relied upon to obtain data showing the stresses under live-load conditions. Having obtained extensometer readings for the four increments of static loading and also having recorded the deflections of the various parts of the car body for the same conditions, a

ratio was established between deflection and stress which naturally held good for live loads as well.

Live Load Stresses

Deflection readings under dynamic loadings were taken for the same points as covered by the extensometer for each loading. The vertical impact or drop was obtained by placing wedge blocks on the rails in front of the car, located one on each rail approximately 2 in. apart longitudinally. The car was then slowly pulled over these blocks, thus producing first an impact on one side and then on the other, which not only caused a straight impact, but a rolling effect as well. The latter may be likened to the rail-joint condition.

The heights of the wedge blocks progressively used were ½ in., 1 in., 1½ in., 2 in. and 2½ in., purposely graduated so as to provide equal height increments. The

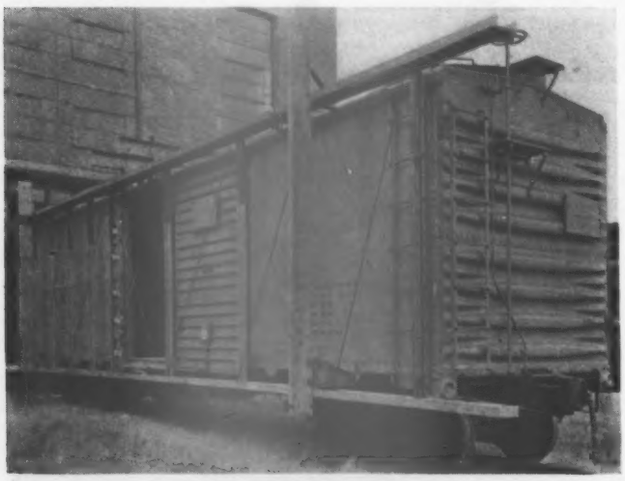


Fig. 3—General view of a car with framework for test instruments

maximum height was arrived at after many tests had been made of other cars. These had indicated that distortion of car structures under this condition was in excess of any distortion occurring in service on the road.

The records thus obtained made it possible to plot deflections for the various degrees of live loading. The static stress curves were then extended to cover the live or dynamic load conditions, using for this purpose the established stresses proportionately between the two curves. In this manner were obtained the stress readings for the maximum dynamic load conditions which, so far as is known, may be anticipated under all dynamic load forces other than those occurring as the result of buffing or end forces.

Conclusions Based on Stress Test Results

Study of the readings and comparison of the stresses and deflections in the A. R. A. standard carbody structure with those found in the two earlier designs tested indicates that the new car is stressed lower and more uniformly in its essential members than either of the other two, even though for equivalent size and capacity it is some 3,500 lb. lighter and some of its sections are smaller.

Furthermore, localization of stresses generally prevalent in other previous car structures have been eliminated and the action of the new body design under test has given definite indication that any loads applied thereto will not bear unduly at any one point within the structure, but will produce relatively smooth, well distributed stress conditions which should be reflected in terms of satisfactory service life and maintenance costs.

Impact Tests

At the conclusion of the deflectometer and extensometer tests the same three designs of box cars were subjected to a series of severe impact tests under full load. All cars were equipped with the latest design of "Dreadnaught" corrugated steel ends in order that they might have the benefit of the same degree of superstructure protection under impact. The same two draft gears, type M-17, with $2^{11}/_{16}$ in. approximate travel, were used in all impact tests. For A.R.A. standard and A.R.A. tentative designs full end loads are delivered through the draft gears to bolster center filling castings. For U.S.R.A. design the end loads are delivered through rear lugs to draft sills and through draft gears to bolster center filling castings. The couplers used on the A.R.A. standard cars were Type E with swivel shank and vertical yoke, single key; with tentative A.R.A. cars; Type E with rigid shank and vertical yoke, single key; with U.S.R.A. cars, Type D, swivel butt, with horizontal yoke, two keys. The roofs on A.R.A. standard and U.S.R.A. cars were "solid steel" with outside carlines, no vertical rivets. Those on the tentative A.R.A. cars were riveted steel with inside carlines.

Two cars of each design were used in each test, one at rest as the "struck" car and the other in motion as the "striking" car. The tests were made over a half mile stretch of level tangent track. Two feet in advance of the struck car, measured from the striking face of the coupler, a stake was driven into the ground adjacent to the running rail. Then, at distances of 52.8 ft. from the first stake, second and third stakes were similarly located. These stakes were positioned so as to be knocked down when contacting with the front journal box of the striking car. Ten feet beyond the third stake a marker was placed at the side of the track.

The striking car was then coupled ahead of a switching locomotive equipped with a speed indicator. Each run was started well beyond the marker so that an approximately constant speed could be maintained for some distance before reaching the marker. At this point the speed of the locomotive was retarded, thus permitting the striking car to separate from and move, independently of the locomotive, the remaining distance to the struck car.

At the beginning of each test two or three runs were made at progressively increased speeds with the maximum slightly below that required to close the draft gears on the two cars. This procedure was for the purpose of determining as closely as practicable the draft-gear closing speeds; i.e., the speed at which the first over-solid blows were delivered. The actual speed at instant of impact was determined by means of stop-watch readings.

Before each run coupler knuckles were opened and locks blocked in release position to prevent coupling and so that the blows would be delivered to the faces of the couplers without throwing them out of line. In addition, loosely fitted blocks were inserted on each side between the striking casting walls and the coupler shanks.

Each series of tests was run in two sections, the first being continued under progressively increased speeds until the rapidly developing wedging action of the loads in the struck ends of both cars had caused the corrugated steel ends to bulge outwardly approximately 2½ in. This procedure was followed so that each car body might have full benefit of the structural resiliency under impact which these ends are designed to provide. This

characteristic not only assists the end and its fastenings to resist the effects of shifting loads, but also provides a cushion for the surrounding car structure for protection against impact forces.

The first section included 16 to 18 runs for each car design at speeds ranging from 3 to 10 m.p.h.

At the termination of the first section of each test, the loads were leveled, the protective structures for the impact recorders repaired and restored to original condition and the steel ends were pulled back into normal position. Temporary wooden bulkheads were installed inside the cars at striking ends to provide the structural rigidity required to withstand the dynamic forces and wedging pressures of the shifting loads at the higher and progressively increased collision speeds.

When the cars were again in readiness to proceed the second portion of each test was started at initial impact speed approximately the same as the maximum reached at the conclusion of the first section of the same test. Thereafter the speeds were gradually increased until definite signs of distortion or failure had developed in the underframes or superstructures or both. The second section included five to seven runs at speeds ranging from 9 to 15 m.p.h.

Except for restoring the steel ends to normal position and straightening the door posts, account wedged outwardly by the impact recorder protective structures, no repairs of any kind were made to any car before or after any test.

Preparation of Cars for Tests

One-half of each car body toward the striking end was given a coating of cement, including sides, end, center sill and underframe members and riveted joints, so that the development of strains or distortions as the tests progressed would immediately be disclosed.

For the purpose of measuring draft-gear travel, the approximate point at which each gear first closed solid and upsetting or shortening of coupler and connections, indicating apparatus was installed. In addition, the face of each striking casting was chalked so that visible evidence of coupler horn contact therewith would be produced.

During the past few years impact registering machines have been quite extensively used by freight-claim departments of various roads and although it was realized that readings in proportion to the damaging shocks delivered to the cars not always would be registered thereby, it was decided to obtain and record such readings during the progress of the tests. Accordingly, two types of impact registers: namely, "Savage" and "Stout," were anchored to the floor of each car at the center of the door opening. The limit of Stout register is 9 m.p.h. and of Savage register 14 m.p.h. When these speeds were exceeded the registers were removed.

In efforts to protect these devices against contact with shifting lading, substantial channel-shaped corrugated-steel housings were placed over each machine and heavy continuous 8-in. by 10-in. timbers were positioned laterally on each side of the housings. The ends of these timbers overlapped the door posts, but were not attached thereto. Shorter heavy beams were fitted longitudinally within the housing so as to provide added stiffening against collapse in this direction. Bags of sand forming a part of the lading were then packed around and over this protective structure.

Impacts of 5 m.p.h. or greater, as registered by these machines, are regarded by the General Manager's Association as bad instances of rough handling with respect to lading protection, and such cases are investigated wherever possible.

Comparative Performance of the Three Designs

Although approximately the same number of runs were made with each design during the regular tests average impact speed for the A.R.A. standard cars was the lowest, being 7.33 m.p.h. as compared with 8.26 and 7.96 for the U.S.R.A. and tentative A.R.A. cars, respectively. Therefore, in the following summary of the performance and condition of the standard cars, the effects of runs 24 and 25 of the extra high-speed tests, made only with these cars, have been included. The resulting average impact speeds and kinetic energy inputs are then as follows:

Car design	No. of runs	Impact speed, m.p.h. Max.	Avg.	Total kinetic energy absorbed
A.R.A. standard	25	16.10	7.93	9,674,512
U.S.R.A.	24	15.00	8.26	10,037,762
Tentative A.R.A.	22	14.30	7.96	8,768,698

The steel ends with which all three designs were equipped functioned in accordance with design requirements and no failures occurred either in the ends themselves or the superstructure attachments.

Due to abnormal punishment considerable damage was done to the door posts of all three designs from wedging action of the impact recorder steel housing and protective timbers.

A.R.A. Standard Cars.—After the first series both cars were in their original condition and all rivets were tight.

During the second series only normal deflection of side posts and sheathing plates under the severe wedging action of the loads had taken place and no distortion had developed in the side plates or sills, end sills, underframe parts, center-sill members or roofs. All rivets in bolster center fillers, body center plates and throughout the car bodies were tight. Except for the front faces of bolster center filling castings which had become slightly indented due to contact with the rear ends of the draft gears, these cars had absorbed the punishment to which they had been subjected without change from their original condition.

U.S.R.A. Cars.—As a result of the first series the side posts and sheathing plates had become slightly bulged due to wedging of the loads. The side plates and sills, end sills, underframe parts, center-sill members and roofs remained in normal condition. All rivets in check plates and body center plates were tight, but a

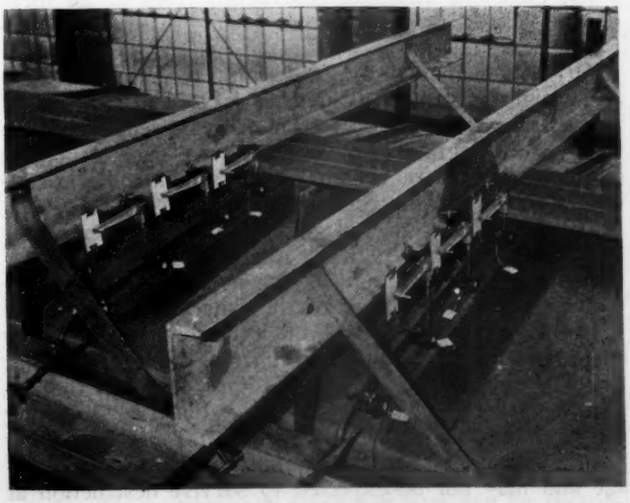


Fig. 4—Top view showing framework and instruments as mounted for testing roof carlines

number of rivets had loosened in the bolster center filler castings. One check plate casting in the striking car had cracked through a rivet boss.

During the second series bulging of side posts and sheathing plates had progressed somewhat further. Side sills and side plates had buckled approximately ⅜ in. at the door openings. End sills, underframe parts, center-sill members and roofs showed no apparent damage. Two additional bolster center filler rivets on one car and one on the other had loosened and check plates on the two cars had developed further cracks. Both car structures had begun to show definite evidence of distress at the conclusion of the tests.

Tentative A.R.A. Cars.—After the first series the side posts and sheathing plates were bulged outwardly to some extent from the action of the wedging loads. Side plates and sills, end sills, underframe parts, center-sill members and roofs were still in good condition. A number of rivets had loosened in the front lugs, bolster center filler castings and truck center plates. Loose rivets were also present in the body center plates of the striking car, but those in the struck car remained tight. Buffing faces of the bolster center filler, striking car, had become slightly indented.

After the second series the bulged condition of side posts and sheathing plates had progressed outwardly somewhat more than was found in the U.S.R.A. cars and this applied also to the corner posts. Side sills and side plates had buckled at the door opening about ⅜ in. End sills were bowed inwardly ⅜ in. at the colliding ends, indicating movement between center sills and side structure. Underframe parts and center-sill members were not damaged. Roof sheets at door opening of struck car had begun to bulge upwardly at the sides. A few additional loosened rivets were found in the bolster center filler castings, also one each in the truck center plates at the colliding ends. This applies also to two body center plate rivets in the striking car. A tendency for the bolster center filler castings to shift had developed. Under the last impact made at 14.3 m.p.h. both cars were knocked off the center plates at the non-striking ends which resulted in some damage to related parts. Both car structures were in distress at the conclusion of the tests.

Conclusions from First and Second Series of Tests

(a) Under all normal operating and service conditions, including switching operations, cars of all three designs tested are capable of giving satisfactory performance.

(b) Although a different design, cross-sectional area and weight of center-sill member is used in each of the three designs, any one of them may be relied upon to survive disintegration of the respective superstructures and related underframe constructions under collision conditions leading to destruction of the cars.

(c) Due to design and application the bolster center filler casting of the A.R.A. standard car may be expected to remain tight and in proper position and to give better service than either of the other two designs.

(d) Experience gained through the action of the heavy corrugated steel housing and timber blocking installed at the door openings of all three designs to protect the impact recorders indicates definitely that at switching speeds having upper limits of 5 to 6 m.p.h., lading ordinarily handled in box cars is subject to severe damage and may not be expected to survive destruction at the higher speeds under which steel-sheathed car structures of reasonably good design begin to fail.

(e) Considering the performance of each unit of equipment as a whole, the A.R.A. standard cars demonstrated their capacity to absorb abnormal collision punishment under full axle load without damage of consequence, whereas both the U.S.R.A. and tentative A.R.A. car-body structures showed unmistakable evidence of approaching failure.

(f) Punishment received by the A.R.A. standard cars during this series of impact tests was not sufficient to provide further check on the necessity for making changes in design as reported in the extensometer and deflectometer test report, but such evidence was developed from succeeding tests of these cars.

Performance of A.R.A. Standard Design under Extra High Speed Impacts

Four runs were next made at average impact speed of 16.21 m.p.h. and maximum of 18.30 m.p.h. Total kinetic energy absorbed was 5,641,500 ft. lb.

Condition of protective housing for recorder and blocking at door opening of U. S. R. A. striking car after tests at maximum speed of 10.25 m.p.h.

Definite distortion leading to failure first developed in the side plates and side sills at the door opening as a result of the side truss buckling and shear action. Moderate bulging of side posts and sheathing plates resulted from wedging action of the lading. End sills were bowed inwardly at the striking ends and outwardly at the opposite ends, indicating horizontal deflection of bolsters with resulting small relative movement between center sills and side structures. Floor support and cross-bearer diaphragms had bowed correspondingly and bottom cover plates of the latter were kinked downward between the center-sill members due to the superstructure buckling effects. No indications of distortion or failure were present in the center sills. The roofs were undamaged other than having become bent at the door openings in conformity with side-plate distortion.

Conclusions—Although the action of the car body as a unit had demonstrated the desired degree of design efficiency resulting from uniform distribution of material throughout the structure, it was plainly shown that when collision punishment is carried to the point at which actual destruction begins, the superstructure may be expected to fail before the underframe cross members become distorted to any extent and that the integral center sill would be the last important member to become defective.

Performance when Coupled at Head End of String of Cars

In the final runs one A.R.A. standard car was coupled at the head of a string of six additional empty box cars on which hand brakes were not set up. The load in this car was reduced to one half, resulting in 108,500 lb. at the rail. The striking car retained its full load.

This test consisted of ten runs at average impact speed of 10.1 m.p.h. and maximum of 14.2 m.p.h.

The cars had been turned end for end before these runs and the wedging load caused some bulging of side posts and sheathing plates. Under this reversed end loading the side sills, side plates and end sills immediately began to straighten up, but somewhat more rapidly in the struck car than in the striking car. At the conclusion of the tests both car superstructures and end sills had lost practically all distortion with no bad effects, and this applied also to the underframe cross members, except for the kinks in the cross-bearer bottom cover plates. The roofs had straightened up and were undamaged. Striking castings had not been damaged.

A number of slightly loosened rivets were found in the bolster center filler castings; also in the body center plates and diagonal braces where they had loosened up considerably. Some of these defects probably had developed during the immediately preceding high-speed runs. On the struck car the contact faces of bolster center filler at B end had not changed, but at the A or struck end indentations on the left-hand face had increased in depth from ⅛ in. to 3/16 in., while the right-hand face remained the same.

Because of extreme progressive hammering received by the bolster filler castings, which finally caused only slight loosening of a small portion of the attachment rivets during the concluding collision tests, it is considered unnecessary and inadvisable to attempt alteration of the design in efforts to guard against development of relatively slight contact face indentations. Preservation of tight rivets is of much greater importance.

Check of the center sill on struck car, which had been squeezed at the head of the string, showed only small horizontal and vertical variations from the straight-line base. Both cars benefited from the reversal of impact loading and, as a result, required less reconditioning than would have been necessary if the final test had not been made.

Conclusions—The integral Z-bar center sill of the standard car is capable of withstanding as a column under dynamic loading, without distortion or failure, a degree of collision punishment which first would cause failure in the superstructure of the car. Further, it is capable of withstanding, without damage, impact blows of sufficient intensity to cause loosening of bolster center filler attachment rivets even though the design of this casing, together with arrangement and utilization of rivets therein, is superior to either of those embodied in the U.S.R.A. or the tentative A.R.A. underframe constructions.

Changes Made in A.R.A. Standard Design

From the knowledge gained during the stress tests it was found practicable, by making a few minor changes in the design of the new standard car "as built," to improve the structure by reducing somewhat the higher stresses found through better distribution of the materials used. While these higher stresses, even under the most severe conditions, are well within the yield point and, therefore, provide adequate factor of safety, obviously it was desirable to investigate the causes of any sharp reversals or sudden changes of stresses and to improve the design accordingly.

These changes, briefly, consist of (a) change in the top rear portion of the bolster center filler casting; (b) change in reinforcement at the side sill under the door opening; (c) application of pressed pan-shaped fillers between the center-sill members in line with the cross-bearer diaphragms, and (d) increase in the width of the bolster top and bottom cover plates.

Collision performance results under high-speed impacts provided a further check on the desirability of making the changes which have been incorporated in the drawings now issued for the Supplement to the Manual.

Brake and Draft Gear Action

(*Continued from page 321*)

corresponding to a car weight of

$$3130 \times 32.2 = 100{,}786 \text{ lb.}$$

and would thus occur when the cars are loaded to about 75 per cent of their capacity.

The maximum occurring car retardation, according to equation (4) if an adequate gear were used, would not exceed

$$a = \frac{F\,(n+2)}{2M} = \frac{6000 \times 152}{2 \times 3130} = 146 \text{ ft. per sec. per sec.}$$

and the maximum occurring coupler pressure in such a train would never exceed the closing pressure of the above draft gear.

If the force closure diagram of said gear were of triangular shape, the closure being proportional to the applied force, the pressure would not exceed

$$P = \frac{2 \times 61{,}400}{.273} = 450{,}000 \text{ lb.}$$

If the gear had an initial compression of say 50,000 lb. and a straight compression line the final pressure would be reduced to the more moderate value of 400,000 lb.

The above rules refer only to draft-gear characteristics required for successful emergency braking. Satisfactory switching service requires, of course, that the gears must be able to cushion the car impacts without going solid and without developing excessive gear reactions. If the gears meet this additional requirement, they will also be adequate to take care of any shocks in train operations which may be caused by free slack.

Baldwin Power Reverse Gears

AN improved power reverse gear embodying an adaptation of the Ragonnet principle has been developed by the Baldwin Locomotive Works, Philadelphia, Pa., The valve controlling the passage of air or steam to and from the cylinder is of the rotating, flat-seat type, made of a non-corrosive alloy and provided with a double seal for the exhaust.

A new feature is a separate valve seat which is readily removable so that both valve and seat can be reground at the bench. A change of valve and seat can be made

without disturbing the piping or any part of the mechanism, except the valve cover which is held by four nuts.

The operating mechanism includes a centering device which moves the valve to its central position as the piston comes to rest and holds the valve in this neutral position until it is moved by the operator. This decreases the tendency to creep and reduces the amount of air used. The application of a guide consisting of bronze bars bolted to a lug integral with the valve chest prevents vibration of the floating lever, which, if permitted, tends to cause leakage of the valve and wearing of pins and shaft bearings.

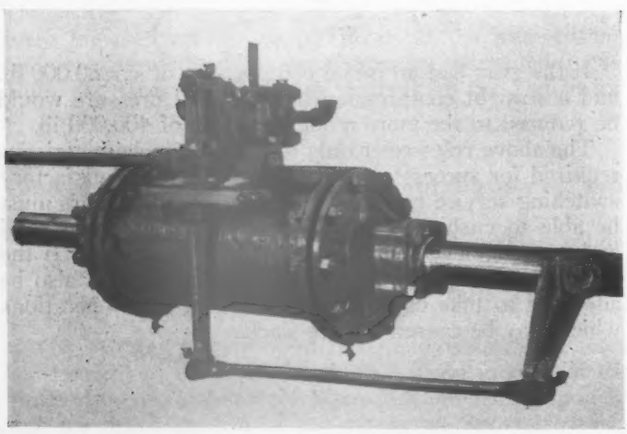
The Baldwin gear has separate air and steam supply pipes so that either source of power can be used, non-corrosive ball check valves being provided to prevent steam from entering the air pipes, or vice-versa. A test cock is included so that a steam test can be made without operating the gear.

The new gear is made in two types, one having a crosshead and guides and the other a trunk-type piston rod. The cylinder and valve assembly are identical in both gears.

The crosshead gear, Type C, has the conventional arrangement of guides cast integral with the cylinder head, and a crosshead which carries the reach-rod connection. The piston-rod packing is interchangeable with that of the 11-in. air pump and 8½-in. cross-compound compressor.

The trunk gear, Type T, has the simplicity and compactness desirable for some installations. The piston is guided by an extended piston rod of large diameter, made from double extra strong steel tubing. The piston-rod extension can be omitted if limited space demands a very short gear, but this is not recommended, since the large piston rod gives an overbalanced pressure on the piston which has a tendency to cause the gear to creep.

The gears can be assembled in a number of ways—with reverse-shaft connection either forward or backward; with the floating lever inside or outside the cylinder; with the valve mechanism above or below the cylinder. Locating the valve below the cylinder is sometimes desirable when steam is used because of the drainage feature of this assembly.



Baldwin reverse gear—Trunk type

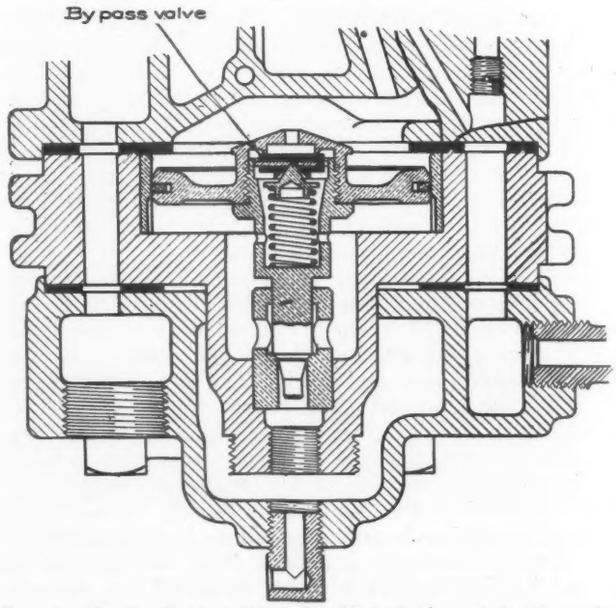
The hand lever in the cab is of an improved type. The latch has been simplified and the latch guide is made integral with the lever. The lever can be furnished with rod connection either above or below the fulcrum, also with a shaft to offset this connection to clear other parts of the locomotive. The application of a booster latch can be arranged when required.

Improved Equalizing Piston for H-6 Brake Valves

AN improved equalizing piston for the H-6 brake valve has been developed by the New York Air Brake Company, 420 Lexington avenue, New York. The piston performs all the functions of the collapsible type equalizing piston and is applicable either to new type brake valves with by-pass grooves, or old type valves without by-pass grooves.

The purpose of this piston, as well as the collapsible type piston, is to relieve any overcharge to which the equalizing reservoir may be subjected so that the equalizing reservoir and brake-pipe pressures may be at or near a balance at all times during the release manipulation of the engineer's brake valve. This is essential for example, in effecting two-application stops.

Referring to the sectional-drawing, it will be noted that a rubber-seated by-pass valve has been incorporated in the piston. This valve is seated upwardly by a spring against a seat formed in the piston head. The proportions of the parts are such that should the differential on the opposite sides of the piston exceed 2½ lb., the valve will open and allow the excess in the equalizing reservoir above the piston to flow to the under or brake-pipe side of the piston. The valve is well protected from excessive deposits of foreign substances.



Improved equalizing piston for H-6 engineer's brake valve

By using this piston it is unnecessary to send brake valves back to the manufacturer to have the grooves put in the piston bushing as is required when collapsible pistons are applied. Furthermore, there is no possibility of the piston head sticking below the by-pass grooves and making it impossible to effect a service application. The improved piston never uncovers these grooves even though this type of piston is substituted for one of the collapsible type.

A RECORD TANK. The Delaware & Hudson claims some sort of record for its recent handling of a creosoting cylinder 80 ft. 10 in. long, weighing 44 tons. The cylinder was handled on two flat cars over a 14-deg. curve at Minooka, Pa., without shifting.

EDITORIALS

The Cost of Creeping Gears

How many power reverse gears on steam locomotives now in daily operation in this country "creep" and how much does this creeping cost the railroads in wasted fuel and loss of locomotive efficiency? In answer to the first question, it may be stated that a great majority of present reverse gears creep more or less, dependent upon their type and general condition as regards maintenance. No one knows the answer to the second question, but the cost is unquestionably of considerable magnitude and probably much larger than commonly appreciated. It is represented in extreme cases, for example, by the difference in fuel and water consumption rates when operating with at least 20 per cent larger cut-offs (and restricted throttle openings) than would otherwise be required for locomotives to develop an equivalent power output.

The normal power reverse gear piston or crosshead stroke is approximately 18 in., 9 in. forward and 9 in. backward. In either corner, the cut-off approaches 90 per cent and is reduced to zero at the center. Cut-off modification, therefore, averages 10 per cent per inch of crosshead movement. Experience shows that, with a reverse lever position which is expected to give a cut-off of 80 per cent, the reverse gear crosshead will frequently creep back and forth over a range of one inch, the actual cut-off, therefore, ranging between 75 per cent and 85 per cent, a variation of 12½ per cent. The amount of creepage is practically constant for any reverse lever position which may be used since it is essentially dependent upon operating design, valve lap and lead, and the amount of lost motion in connections. With a 30-per cent mean or desired cut-off, therefore, this 10-per cent variation becomes 33⅓ per cent of the expected cut-off movement instead of only 12½ per cent, as was the case with the longer cut-off.

What difference does this excessive gear movement really make and what can be done about it? The effects at long cut-offs appear to be relatively small, but at short cut-offs, the variations in the sound of the exhaust and the effect of draft fluctuations upon the fire become seriously objectionable. The only thing the engineman can do to overcome these difficulties is to move the reverse lever nearer the corner and partially close the throttle. Assuming that the work to be done by the locomotive permits using a 30-per cent cut-off with a full throttle, but that reverse-gear creep increases this cut-off to 50 per cent (by no means an unusual increase), the throttle must be closed partially in order to avoid the development of an excessive amount of power and speed. The result is a loss in economy represented by the difference between the water and fuel consumption rates which obtain, on the one hand, with 30-per-cent cut-off and full throttle, and, on the other hand, with a 50-per-cent cut-off and partial throttle. What this means in dollars is not as definitely known as it should be. The amount, in the aggregate, however, is large enough to attract the interest of all railway officers responsible for maximum results in locomotive operation.

Restore a Sane Policy

Although there has been a decided reduction in the rate at which deferred maintenance of cars and locomotives has been accumulating during the recent spring and summer months, the railways as a whole have not yet built-up their equipment-repair programs to a point where they are keeping even with the demands for repairs which current use is creating. Four years' accumulation of deferred maintenance has yet to be dealt with. Sooner or later, with the advance of general business recovery, the growth in the volume of traffic will be such that the problem of restoring the large accumulation of worn-out equipment to service will have to be dealt with. When that time comes some conditions which did not exist, or at least were not so pronounced, during the years immediately prior to the depression will have to be taken into consideration.

During the past four years there has been a marked change in maintenance policy. Perhaps it would be better to characterize the change as an absence of policy, at least in the long-term sense. Such policy as the railways have had has been one of expediency—of reducing expenditures at any cost. This has resulted in an increase in the practice of fabricating materials and manufacturing parts which, during normal times, were supplied by purchase. In many cases, the curtailment in purchases of necessary materials left no other recourse open to the officers and supervisors of the mechanical department.

This tendency has also been accelerated by the natural desire of the railway managements to supply as much work as possible for their own employees during the emergency. It has led in some cases to undertaking the manufacture of parts for which the railway shop organization is ill-fitted by training. In some instances

the lack of appreciation of the essential value of correct materials has been very costly. In other cases the lack of adequate engineering, particularly as related to the cheapening of production costs, as well as a lack of knowledge of the whole subject of production-cost finding, make the results economically unsatisfactory.

Another condition which has been rapidly changing during the depression is the reduction in shop capacity which the concentration of repair work in central shops, accompanied by the permanent closing of outlying plants, has effected. When it becomes necessary to deal vigorously with the accumulated deferred maintenance this reduced shop capacity, although now in excess of actual use, may soon be overtaxed.

The roads will then face the necessity for a reconsideration of maintenance policies. Shall they continue their extended manufacturing operations and take up the maintenance slack by contracting for repairs with outside plants, as was done in the case of the accumulation of deferred maintenance following the end of U.S.R.A. operation and the strike of 1922, or shall they curtail manufacturing and fabricating activities, and utilize all of their facilities to the utmost for the reconditioning of existing equipment, depending upon a liberal retirement program to take care of the excess?

In following the first alternative during the years following the strike of 1922 the railways restored many obsolete units of equipment through outside contracts, the later performance of which scarcely justified the high costs of the repairs and betterments. The railways know that the lack of proper facilities for locomotive repair operations did not make for economy on many of these maintenance contracts. Do they recognize that a similar lack of facilities for production operations are inimical to economy of manufacturing operations in railway shops?

Many operations of a manufacturing character have been undertaken in railway shops on the theory that idle space and facilities were available and, therefore, only immediate out-of-pocket costs need be considered in competition with commercial prices. But when equipment-repair operations again tax the capacity of existing shop facilities the continuance of such operations can then only be justified if the full cost of space and facilities, with the proper share of other overhead items, are taken fully into account when comparing with commercial prices. Then the time comes when the apparent savings to the railroad, based on the idle-capacity theory, are used as an argument to justify additional investment to expand the plant in order that such operations may be continued or expanded.

Can the railways justify the use of their credit for the expansion of facilities far removed from the production of transportation when such facilities are already available without financial risk to themselves? The best results can scarcely be obtained by contracting with outside manufacturers for excess repairs and devoting repair-shop facilities to manufacturing operations.

Concerning Conventions Next Year

The comments which we published in the July and August numbers of the *Railway Mechanical Engineer* as to the possibility of holding conventions of the Mechanical Division and the other railway mechanical associations next year, have brought forth many reactions from both the railway men and the railway supply representatives.

The Mechanical Division, through its General Committee, has already decided to hold a full membership meeting next year. Whether it will be accompanied by exhibits depends upon the Railway Supply Manufacturers' Association and this, in turn, will depend upon the improvement of business conditions between now and the time that it will be necessary to make the decision as to whether or not the exhibits will be held. The situation is made more complicated by the fact that this decision must be made many months in advance of the convention, because of the large amount of detail work involved in organizing and arranging for the exhibits.

In general, the suggestion that some arrangement be made whereby all of the mechanical conventions meet at about the same time, in order that the railway supply people will be warranted in putting on one large exhibit, seems to meet with considerable favor. Most of the railway supply people express enthusiasm over the possibility of making an exhibit, provided an adequate attendance can be assured, and also, of course, that business conditions will be such as to warrant the necessary expenditure. Many of the railway supply representatives feel strongly that the expense of setting up an exhibit is so great that some plan should be worked out whereby only one exhibit will be necessary for all the associations. This might be made possible and at the same time not take too many key men from the railroads at one time, by having the Mechanical Division meeting immediately preceded and followed by some of the other association meetings—a week-end intervening either before or after the Mechanical Division meeting.

The consensus seems to be that Atlantic City is the only place that can house the large exhibit. There is the feeling in some quarters, however, that the attendance at the minor mechanical association meetings may be adversely affected if they are scheduled for Atlantic City, because of the long distances that will have to be covered by members from the western railroads. Most of these associations have normally held their meetings in Chicago, because of its more central location and greater accessibility for the men in the Middle West and West.

The officers of the mechanical associations other than the Mechanical Division, are scheduled to meet at the Hotel Sherman, Chicago, on September 17 and 18, to consider the question of holding conventions next year. There is a certain sentiment that it might be advisable

to have these associations hold their annual meetings in Chicago, and have a special exhibit for them. This would necessitate many of the railway supply companies arranging for two exhibits, one at Atlantic City for the Mechanical Division, and one at Chicago for the other mechanical associations.

There is a question as to whether, if only the Mechanical Division meets at Atlantic City, it will be advisable for it to spread its meetings over a sufficient length of time to justify the big exhibit at that place. Obviously the exhibitors will hardly be warranted in putting on a big show if the Mechanical Division will only meet for two or three days. There is, of course, always the possibility of the Purchases and Stores Division scheduling its meeting at about the same time as the Mechanical Division, and at the same place, thus enabling the Purchases and Stores officers to enjoy the advantage of the exhibit.

If all of the mechanical associations meet at Atlantic City at about the same time, possibly spacing their meetings over a period of eight or ten days, there is little question but what, under reasonably good business conditions, the railway supply people will be warranted in putting on an exhibit; indeed, many of them have expressed themselves enthusiastically in this respect.

There appears to be a strong possibility that some of the associations may have to change their procedures or practices more or less radically, or even to modify their forms of organization. The past four years have witnessed many changes in personnel in some of the departments. In addition to death and retirements, many officers and foremen have left the service or have been demoted, their positions being abolished. Consolidations of railroads, closer integration of subsidiaries, concentration of repair facilities, and changes in methods and practices have all combined to complicate matters.

On one system, for instance, which since 1930 has absorbed two smaller railroads, one man only is available today for membership in one of the important mechanical associations as compared to seven men in 1930. Meanwhile large improvements have been made and others are impending which make the work of this particular association of unusual importance to the railways at this particular time. While the instance cited is admittedly extreme it discloses a tendency which promises to affect all of the associations.

The issue must be met fairly and squarely and we must carry on. It will be interesting, for instance, to explore the possibilities of joint sessions on overlapping subjects, or those which may be common to two or more groups. Such things as this may make advisable closer co-operation between the different associations and may go a long way toward justifying joint meetings and a common exhibit.

The situation is so complicated and has so many angles that there will naturally be objections from some group or groups to any arrangement which may be suggested. The task, therefore, is one requiring careful study and a certain amount of compromise on the part of some of the groups, in order that the most satisfactory arrangement may be decided upon in the interests of the railway mechanical department and the railway supply fraternity as a whole.

Getting Results In the Coach Yard

In response to an inquiry regarding the principal things essential to getting desired results in coach-yard operation, a supervisor recently placed first emphasis on the need for adequate facilities for steaming and watering cars. This means ample capacity in the power plant and pumping equipment, pipe lines in good condition, with couplings conveniently located and easily engaged. Water hydrants should be so designed as to provide for rapid hose coupling, with drainage provided below the frost line for use in winter. The mains should be large enough so as not to restrict either the supply of water or the water pressure.

Another important feature is the co-operation of the operating department with respect to the location of special and extra trains when regular yard space is not sufficient to accommodate the additional business. Walkways throughout the coach yard should be maintained in good condition at all times to speed up and simplify the handling of supplies, materials, etc. Considerable time can be save by using tractors in supplying coal and ice, providing these walkways are not only kept in good condition but the space between tracks is maintained wide enough to permit passage of the tractors.

The proper arrangement of repair pits to accommodate a group of cars so that repairs can be performed in a progressive line without undue delay occasioned by switching is essential. Obviously, the operations are greatly retarded when repair pits are so located that cars cannot be released until some single car is switched out of the way by a locomotive. The lack of wheel- and axle-turning machinery often causes delay to equipment and all large coach yards should be made self-supporting in this respect. Numerous problems arise in connection with the cleaning of cars, and it is essential that foremen constantly check their work and forces to maintain clean cars at a minimum cost per unit cleaned.

In connection with general coach-yard operation, the emphasis on elimination of personal injuries should never be allowed to lapse, since almost no department possesses greater possibilities of accident. Supervisors should be ever on the alert to educate the workmen and to help the ambitious employees who are anxious to advance as a result of their own efforts. Such men should be encouraged and assisted in their efforts to study and qualify themselves for positions of greater responsibility.

With the Car Foremen and Inspectors

Jack for Handling U. C. Valves

A CONVENIENT, portable jack for use in removing and applying U. C. universal valves, reservoirs, brake cylinders, etc., to passenger cars is shown in the illustration. It consists of a steel A-frame suitably reinforced and equipped with two small truck wheels on the wide leg of the A-frame and with a swivel caster on the other narrow side of the frame. A square-thread screw, provided with a collar and four small projecting handles for turning it, is applied through suitable holes in the top of the A-frame and the cross brace, being threaded into an elongated nut which is welded to the A-frame to prevent turning. The upper end of the screw is equipped with a revolving special saddle which turns readily on the screw and which also is removable so that a saddle of different shape can be substituted, if required.

This portable jack for use in applying air-brake parts underneath a passenger car is light and easily handled, and it not only greatly facilitates the work but also contributes to safety, since the more or less heavy air-brake parts can be applied without the use of make-shift blocking which is likely to slip and cause accidents.

Portable jack for use in applying and removing passenger-car air-brake material

Machine Practice in the Car Wheel Shop*

THE importance of proper methods of mounting wheels can hardly be over-estimated, not only in relation to shop costs but as an outstanding factor in wheel performance. It is, therefore, only logical that if the best machine-shop practices of the many wheel mounting shops are brought together and formulated into standard rules of practice, it will result in far greater uniformity of methods and more satisfactory results in mounting wheels.

To do good machine work of any kind, the equipment must be rugged enough to stand the punishment it will be subjected to. Of equal importance is the necessity of keeping the machines in good condition. Worn machinery makes it almost impossible to produce work without taper or chatter marks and, where this occurs in the surface of the axle-wheel seat or the bore of the wheel, the desired consistent mounting pressures in pressing the wheel on the axle cannot be obtained.

Axle Lathe Practice

The lathe is too light. The ways are worn. The centers are worn and gouged. These three conditions, or some combination of them, make up the common diagnosis of poor axle work. The correction of the first two are obvious. The worn and gouged centers can be renewed.

Because of the severe punishment that an axle lathe center must stand and because of its extreme importance in producing accurate machine work, it is suggested that the old fixed or dead center be replaced by a roller-bearing center. While the initial cost may be relatively high, the superior performance plus the lower maintenance cost justifies its use. Due to the fact that the roller-bearing center rotates with the axle, it is possible to grind it to 77 deg., and thus handle axles with either 60-deg. or 77-deg. centers.

Axle Lathe Tools

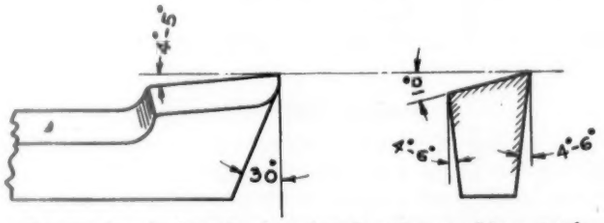
Even with equipment in excellent condition, unquestionably, the most important factor in machine work is the design of the tools. All cutting tools can essentially be considered as wedges forced into the material to separate it. A tool with a thin edge cuts more easily because less friction is generated; it distorts the chips less and removes them with greater freedom. In order to withstand a heavy cut at a suitable speed, the tool must be thick enough and also have sufficient width to withstand the heat generated by friction. Excessive heat due to the improper shape of the tool will soon cause its destruction. Also, the material being cut will in part govern the cutting speed. A portion of the heat is conducted away through the work and thence to the air, while the remainder travels from the edge into the body of the tool, from which it radiates to the air. Some heat is

*Condensed from a pamphlet "Theory and Practice of Mounting Railroad Wheels on Axles", published by, and available upon request of, the Association of Manufacturers of Chilled Car Wheels, McCormick building, Chicago.

carried away by the chips, themselves, and by the lubricant if it is used.

The cutting angle or keenness of the tool is either increased or decreased by changing the rake angle of the tool. Generally speaking, cast iron is successfully cut with the cutting angle of between 70 deg. and 80 deg. and steel with an angle from 40 deg. to 60 deg. Not only must the tool be ground to the proper angle, but also of vital importance is its height relative to the axis of the work in the lathe.

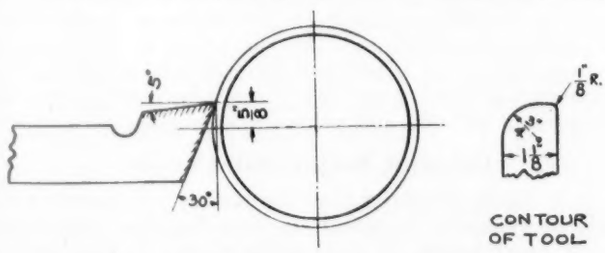
When the tool is set below the center, the effect is to rapidly decrease the front rake and increase the clear-



Correctly designed right-hand axle-roughing tool

ance, and, as a result, cause the tool to tear the metal instead of cutting it. The effect of wear in the lathe on the quality of work it is capable of doing, is also aggravated by setting the tool below center. A tool set too high above center may go so far as to eliminate all of the front clearance and thereby compel the tool to ride on the work and destroy the edge by friction. In other words, the front clearance on the tool governs the maximum amount that the tool can be set above center and still be able to cut.

Theoretically, the angle between the horizontal and the line drawn from the center of the work through the cutting edge of the tool should be equal to the end clearance angle of the tool. When set at this theoretical height, however, the tool has no effective end clearance so that, in practice, it is set slightly below this point. In no case should it be set higher. Hence, eliminating other



Preferred design and setting for axle finishing tool

considerations, the diameter of the stock being turned and the clearance on the tool govern the height that the tool can be set above the center. When turning large diameters, the tool can obviously be set much higher and still retain ample clearance.

The shape of the tool, in the final analysis, is governed by the material to be machined, and must satisfy the physical properties of the metal it is cutting. When machining cast iron, the chips break off short, due to the graphite, and, in reality, the tool is cutting and then breaking off the metal. Steel, however, because of its ductility and tenacity, must be cut or shaved off and hence the chip should come off in continuous smooth curls.

The condition of the lathe also influences the correct heights at which the tool should be placed. The only reason for placing a tool above the center line of the work is to eliminate chattering of the tool. Hence, when working with a lathe that is worn, the tool, out of necessity, must be set unusually high to eliminate this defect, at least partially.

It must be borne in mind that first of all, for a given material which is to be machined, the first elements of consideration are the "angle of approach" and the "angle of keenness." Having once established these angles, then the remaining angles, namely, the front clearance on the tool, and the height above center at which the tool is to be used, are elements of design which are dependent upon the condition of the lathe and the diameter of the work that is to be turned.

Axle lathes are expected to work within comparatively close limits and yet are subjected to extreme punishment. As a consequence, after a comparatively short period of service, they develop sufficient vibration and it is necessary to design tools so that they will at least partially compensate for the condition of the lathe. The present A. R. A. Wheel and Axle Manual shows the tool set 3/16 in. above center. However, the practice at wheel shops, with very few exceptions, is to set the tool from ½ in. to as much as 1 in. above center, invariably being higher on lathes which have become worn.

Another important factor in tool performance is the life of the tool. It is quite evident that the keener the tool, the less punishment it will withstand and the sooner it will require grinding. Therefore, the cutting angle should not be any more acute than is necessary to cut the material. Excessive rake and an unnecessary amount of clearance lead only to short tool life. Tool clearance above what is actually required for proper performance is probably responsible for the greater portion of tool failures.

Heat Treatment and Grinding

The heat treatment and grinding of tools is also of paramount importance. Each type of tool steel can deliver satisfaction only when carefully and properly heat-treated. The best steel which can be produced, regardless of cost, will not do the work expected if it is improperly hardened. The manufacturer of the steel is in the best position to recommend the proper treatment, and his advice should not only be sought but followed.

Hardened tools can easily be ruined by careless grinding technic. Local high temperatures, caused by too great a pressure against the abrasive wheel, result in grinding cracks. This is particularly true of high-speed steel. Also, an abrasive wheel which is too fine or too hard does not cut but, instead, burns the steel. During grinding, tools that have become hot should not be quenched in cold water to cool them for it almost invariably causes minute cracks. When possible, grinding should be done on an abrasive wheel on which a generous supply of water is flowing and thereby prevent overheating of the tool. If conditions permit, the most consistent quality of work can be obtained when all tools are ground in the tool room by a trained man who is charged with this responsibility.

The grinding operation invariably leaves a coarse surface on the face and a pronounced feather edge on the cutting edge of the tool. When the tool is placed in service and expected to do quality work, it fails, first, because the feather edge breaks off the instant the tool makes contact with the work, leaving a blunt instead of a keen cutting edge; and, second, because the rough ground face of the tool resists the shavings as they are compelled to pass over it and very soon causes them to pile up and stick on the tool. Either of these two conditions results in a rough finish instead of a smooth surface suitable for rolling. To overcome this, the tool should be honed, to eliminate coarse grinding marks and

remove the feather edge. It can safely be stated that honing adds considerably to the useful life of the tool before regrinding is necessary and greatly improves the quality of a finish cut.

These rudimentary facts are all common knowledge to the modern tool maker, but their observance is of such extreme importance that they must be constantly emphasized.

If all lathes were of the same design, running at the same speed and in uniformly good condition, very definite angles could unquestionably be established on the cutting tools. Unfortunately, these ideal conditions do not exist and, hence, recommendations which involve certain limitations must be made. One of the illustrations shows the shape of a roughing tool to be used for turning axles. This tool not only has a substantial front rake but a decided side rake and should be set about one-half inch above the center line.

Particularly when heavy cuts are taken, a roughing tool of this design will clear itself of chips and require less power. The illustration shows a right-hand roughing tool; a left-hand tool would necessarily have to have a side rake in the opposite direction.

Finishing Tools

The general contour of a finishing tool, as shown in the present Wheel and Axle Manual, has been adhered to, but, in addition, there are very definite recommendations with regard to the amount of rake and front clearance on the tool, together with the height at which the tool should be set. The importance of setting the tool at the recommended height cannot be over-emphasized, and it is, therefore, suggested that axle lathes be equipped with tool posts which will hold the tool at a definite height.

The conventional tool post utilizing either a rocker or step washer for changing the height of the tool is not recommended, since this arrangement out of necessity disturbs the angularity of the tool when its height is changed. If, on the other hand, the shank of the tool is always held in a horizontal position and the height of the tool altered by placing full length straight shims of varying uniform thickness under the tool, regardless of what height the tool is set, the fundamental angles between the work and the tool are not disturbed. Another illustration shows that the tool should be set at $\frac{5}{8}$ in. above the center. This is considered the minimum height, the height actually having to be changed, dependent upon the diameter of the journal or wheel seat that is being turned. In reality, the tool height should be increased until the tool is just on the verge of losing its front clearance, and, as a result, riding, rather than cutting the axle. Then, having established the proper height, it must be maintained at all times, unless perfection of finish is to be sacrificed.

Axle-Lathe Speed and Feed

For roughing cuts, the speed and feed are governed only by the punishment that the cutting tool will withstand. For finishing, however, where the final finish of the axle surface is an important factor, the longitudinal feed is regulated primarily by the shape and width of the finishing tool. In the final analysis, the feed must be sufficiently fine so that the finished surface has the desired smoothness. The finished surface must be as devoid of tool marks as possible, this being particularly true of the journal. When the finishing tool leaves either coarse tool marks or a ragged surface, it is almost impossible subsequently to remove the evidence by the rolling operation.

There are axle lathes running as slow as 34 r. p. m. and as fast as 200 r. p. m. and, consequently, the feeds used are not the same. On the fastest running lathe, a $\frac{1}{32}$-in. feed per revolution is used for both rough and finish cuts. On lathes running a little over half this speed, the rough feed is $\frac{1}{16}$ in. per revolution and finish feed $\frac{1}{32}$ in. per revolution. With the lathe speed down to 35 to 60 r. p. m., the rough feed is $\frac{1}{8}$ in. per revolution and the finish feed either $\frac{1}{16}$ or as little as $\frac{1}{32}$ in. per revolution.

The best finishes are obtained where the tendency is to run at higher rotational speeds and finer longitudinal feeds. In any event, it is impossible to obtain the essential quality of finish unless the final feed is $\frac{1}{16}$ in. per revolution or less. In answer to a question on this subject, 48 out of 69 railroads shops report the use of a $\frac{1}{16}$-in. feed.

Boring-Mill Practice

The boring of wheels is equally important as the machining of axles (in fact, they are inter-dependent). Boring mills used for this work are subjected to severe punishment and still must work within very close tolerances. A mill that has been neglected soon bores wheels that are either out of round or tapered several thousandths of an inch. Although this is primarily caused by excessive play in the boring bar, it is also materially aggravated when excessive cuts are taken or the mill is operated at speeds in excess of what it was designed for. In the final analysis, the depth of cut, feeds, and speed of rotation are determined by the condition of the mill. As a general rule, a feed of $\frac{1}{8}$ in. for roughing and $\frac{5}{16}$ in. for finishing produces the best results.

In addition to checking the condition of the boring bar by carefully calipering wheels bored on the mill, the jaws of the mill should be checked at regular intervals to assure that it is boring concentric with the tread of the wheel and at right angles to the plane of the flange. Probably the simplest method of checking the concentricity of the jaws of the mill is to have a standard ring turned with a contour identical with that on the wheel tread and flange. This ring can then be placed in the jaws of the mill and indicated by clamping a gage onto the boring bar of the mill. An alternative of this method is suggested in the Wheel and Axle Manual in which it is recommended that a portable grinder be clamped to the boring bar and the mill placed in operation.

Grinding Boring-Mill Cutters

It is highly essential that the boring-mill cutters not only be ground to a definite contour but they must also be of equal length so that, when placed in the boring bar, each cutter will take the same depth of cut. If the cutters are not of equal length, it is impossible to caliper the cutters and expect them to bore the wheel the same diameter. Furthermore, if the cutters are of unequal length, there is a tendency for the boring bar to be crowded to one side and the resulting bore will not be concentric with the wheel.

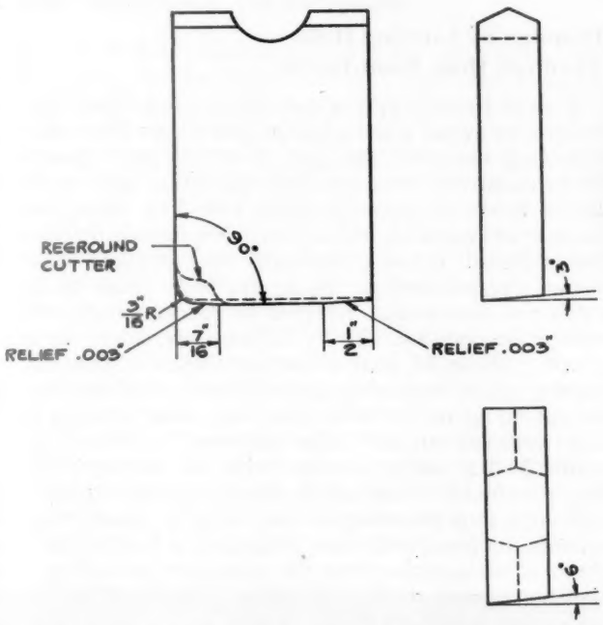
The most satisfactory method of grinding boring-mill cutters is to build a jig which will hold both cutters at the same time, grind them to the same length and establish the proper angles as well. A grinding jig of this kind will soon pay for itself in the form of lower tool costs and consistently good boring practice.

Boring-Mill Cutter

The necessity for having a perfectly cylindrical bore, uniform in diameter and with a smooth finish, can hardly be over-estimated. To accomplish this, the boring-mill cutters must be properly designed and their contour must be maintained. One of the illustrations clearly shows the

essential elements of a boring-mill cutter for boring chilled tread wheels.

It is well to note that, in addition to the 3-deg. clearance on the end of the tool, the leading cutting edge and the trailing edge have been very slightly relieved. Even though the cutters are supposedly rigidly held in the boring bar, under the stresses that they are subjected to when making a cut, there is a tendency for them to yield, particularly when entering and leaving the bore of the wheel. This quite naturally has the effect of taper-boring



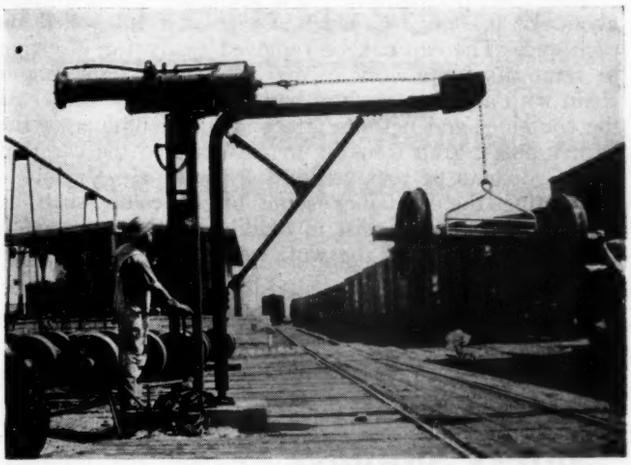
Roughing and finishing cutter for boring cast-iron wheels

the wheel, and experience has shown that, by slightly relieving the tool, this condition is eliminated. The relief on the cutters also assists them in finding themselves in the rough bore and thereby giving added assurance of producing a true finish bore suitable for mounting. As is evident from the drawing, new cutters are used for making finishing cuts, and, after a number of regrindings, are used as roughing cutters.

Air Hoist for Handling Car Wheels

By P. P. Barthelemy

FOR unloading and loading mounted car wheels, a great many devices are used, ranging from a gantry crane, electric, air and hydraulic lifts and depressed tracks to the old-fashioned loading skid. An inexpensive but efficient type of air hoist particularly suitable for handling wheels is shown in the illustration. As will be noted, this consists of a horizontal air cylinder mounted on a swinging boom which is secured to a rigid mast set in concrete. The boom has a wide swing and is so set in relation to the loading and unloading track that the tongs hang over the center line of the car and swing over the loading storage track. The wheels may be handled from and to a parallel or transverse supply track with ease and safety. The handling tongs, it will be noted, engage the axle between the wheels and its members are wide-spread to prevent side slippage. Chains, cables, or any other kind of sling over the jour-

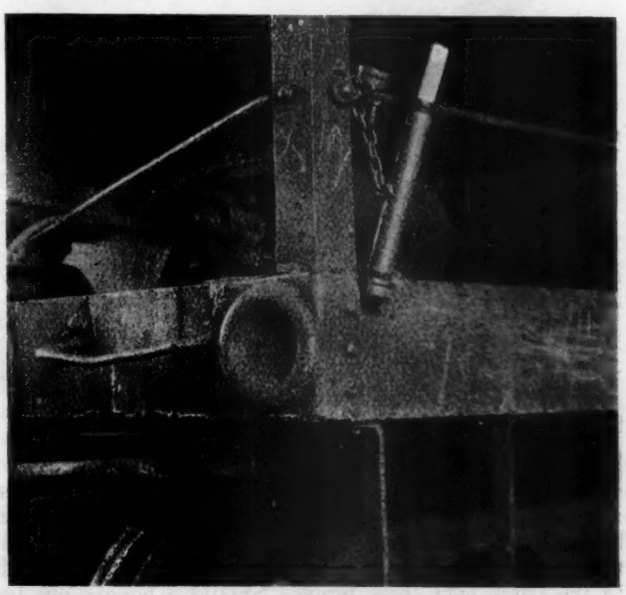


An inexpensive but efficient swing boom and pneumatic hoist for use in loading car wheels

nals are prohibited. This hoist is of such height that it will swing into the doorway of a box car and is useful for loading and unloading bolsters and other heavy materials. When not in use the boom is locked in a clear position.

Container for Work Reports

THE container shown in the illustration is used by the work inspector in the car shop for filing work report cards and at the same time keeping the report



An easily made work report container

with the car so as to give information to the foreman and workmen as to what work is still required. Placing

the work report in the truck springs of the car as formerly done did not prove satisfactory for the reason that it frequently became lost or was soiled by either grease or paint.

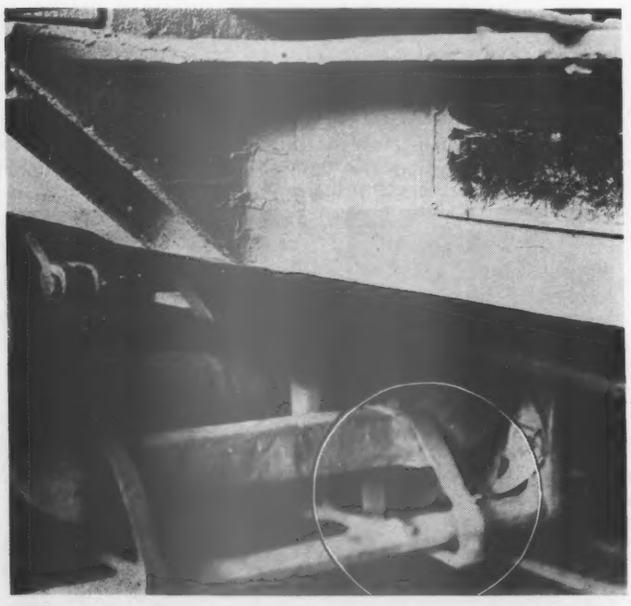
The container consists of a piece of one-inch pipe about 12 in. long to which a pipe cap is applied on each end. The cap can be removed easily for insertion or removal of the work report. A piece of light-weight chain with a spring catch is spot welded to the center of the container and permits attaching the container to the corner posts, grab irons or to any part of the car that is not going to be removed during the repair period.

Painting the container some bright color, such as red or yellow, will assist in readily locating it when it is desired to examine the work report or to make additions to it.

Brake Beam Safety Support

LOCOMOTIVE tenders equipped with six-wheel type cast steel trucks having the "clasp" brake requires the use of six brake beams for each truck. It is impossible to adapt the ordinary freight car brake beam support to these trucks due to the absence of a spring plank, however it is desirable to provide safety protection to the brake beams especially where this type of equipment is assigned to high speed freight and passenger train service.

One method of applying a safety support for the brake beams on this type of truck is shown in the accompanying illustration. The support is made in two pieces to facilitate its removal when replacement of brake beams becomes necessary. Two pieces of ½ in. by 2½ in. wrought iron is formed in the manner shown and bolted to the truck side cross brace. Should a hanger pin be lost out or a brake hanger break while the engine is in service, the brake beam will be supported by the safety support and probably prevent a train delay if not a serious accident.



Six-wheel truck safety support for brake beam

Decisions of Arbitration Cases

(The Arbitration Committee of the A. R. A. Mechanical Division is called upon to render decisions on a large number of questions and controversies which are submitted from time to time. As these matters are of interest not only to railroad officers but also to car inspectors and others, the Railway Mechanical Engineer will print abstracts of decisions as rendered.)

Damage by Cutting Hole Through Door from Inside

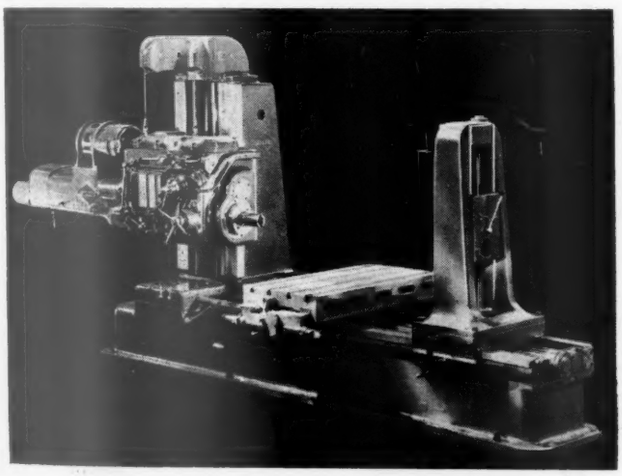
Pacific Fruit Express refrigerator car 4884 was delivered to owner's shop by Oregon Short Line with the following uncarded damage: Two side-door sheathings broken and part missing; hair insulation and insulation paper torn and missing; three side-door lining boards broken and cut with knife. Owner requested defect card, but railroad refused, claiming that damage was car owner's responsibility. Being unable to reach an agreement the matter was referred to the Arbitration Committee for decision. P. F. E. contends, based on paragraph 5, Rule 32, that delivering line is responsible for cutting out or removing parts of cars to facilitate loading or unloading or for other purposes; that parts in question were cut out for "other purposes." Delivering line contends that owner is responsible for damage originating from inside of car and declined to furnish defect card, although it acknowledged that if it is found that the damage involved malicious cutting of a hole in the door there is no question that the company permitting such damage is responsible. Damage was found by outside inspection with side doors closed, and thus it is not a question of concealed damage, such as fire damage or other damage, of which delivering line may be unaware at time of delivery. P. F. E. admits that an interior inspection over interchange is not required, but contends that defects such as under dispute can be and were found by outside inspection and, therefore, is a responsibility of delivering line. Included in evidence submitted by Oregon Short Line was a statement of car foreman giving reason for not issuing defect card, stating that damage was evidently done by some party inside of car cutting way out on inside door and breaking out outside door sheathing boards. Cutting was not visible from outside of car with door closed. When P. F. E. first presented claim they suggested that damage might have been caused by trucks backing against the door when open during loading or unloading as had occurred in a number of cases, but this was clearly not the case. It is acknowledged that the hole in the door could be seen and was found by exterior inspection, but it is contended that the only damage visible from the outside with doors closed was two broken-out side boards and that visible evidence of lining boards being cut could not be determined without interior inspection. Complete statements and correspondence was attached. In substance the O. S. L. contends that principle of section k, Rule 32, and interpretation 5 properly apply and that it is not liable for the cost of repairs.

In decision rendered October 26, 1933, the Arbitration Committee said: "In view of statement by the Oregon Short Line that it has no record of the damage occurring while car was in its possession, it is responsible only for such damage as could be observed from exterior inspection with door closed. Defect card should be issued accordingly."—*Case No. 1732, Pacific Fruit Express Company vs. Oregon Short Line Railroad.*

In the Back Shop and Enginehouse

Horizontal Boring, Drilling And Milling Machine

A NEW horizontal boring, drilling and milling machine, designated as No. 400, has been designed by William Sellers & Company, Inc., Philadelphia, Pa. This is a flexible, rapid and accurate tool, well suited for general purpose work. A prominent feature of this machine is the unit head construction which provides a remarkably short and direct drive to the spindle. All drive, feed and traverse mechanism is contained in one unit with the spindle. This results in rigidity, efficiency and a smooth, steady drive to the spindle. A 10-hp. constant-speed motor, 750 r.p.m., either a.c. or d.c., is mounted on the unit head. Controls for speed and feeds are conveniently grouped on the head where they can be easily reached by the operator. Power traverse or hand movement of head, table and saddle is also controlled from the head, a micrometer dial being provided to indicate movement. A friction clutch reversing mechanism provides for instantaneous start, stop and reversal of the spindle, an advantageous feature in tapping. The spindle is of 4 in. diameter and fitted with a No. 6



Sellers No. 400 horizontal boring, drilling and milling machine

Morse taper hole. There are 24 speed changes, 9 to 500 r.p.m., while feed per revolution of the spindle ranges from .0025 in. to .625 in. The vertical adjustment of the head on the column is 72 in. and the maximum distance from the face of the spindle sleeve to the outboard bearing is 31½ in. The outboard bearing may be easily removed if desired to accommodate long work. The standard table size is 30 in. by 60 in., with a cross travel of 46 in. and a longitudinal travel of 38 in.

Variations in length of bed, column height and size of table may be made to suit special requirements. Among attachments obtainable are boring bars up to 4 in. diameter; circular or square swiveling tables; auxiliary tables; milling cutters; star-feed facing heads for diameters up to 24 in.

Machining Rod Bushings and Valve Packing Rings

SOME indication of the ability of modern machine tools to produce locomotive parts in considerably less time than many of the obsolete machines still in use in railroad machine shops may be taken from the operation studies on two jobs, the details for which are given in this article. The operations outlined and the time given in the case of the rod bushings are taken from production records on a 36-in. Bullard vertical turret lathe and those relating to valve-packing rings, from a Bullard 24-in. vertical turret lathe.

Finishing Rod Bushings

Fig. 1 shows the diagrammatic set-up of turret tools for the first chucking, consisting of three separate operations for the finishing of 8½-in. outside diameter side-

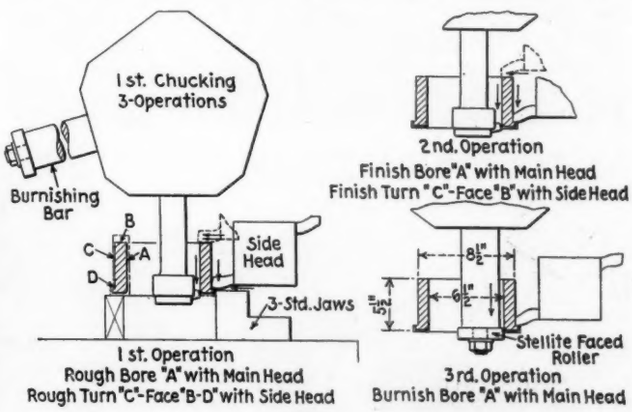


Fig. 1

rod bushings. The first operation consists of rough boring the outside of the bronze bushing casting with a tool in the bar of the main head at the same time that the outside of the bushing is turned with a tool in the side head. At this same setting the surface *B* and the shoulder *D* are faced with a side-head tool. For the first operation a table speed of 60.2 r.p.m. is used which, together with a feed of .068 in., results in a cutting speed of 102 ft. per min. for the boring of surface *A* and 137 ft. per min. for the turning and facing of surfaces *B*, *C*, and *D*. After the completion of the rough boring and turning operation the cutters in the bar are changed and the side head indexed for the finish boring and turning of surfaces *A* and *C* and the facing of surface *B*, which comprises the second operation performed at a table speed of 86.5 r.p.m. and a cutter feed of .068. The third and final operation at the first chucking is the burnishing of the bore of the bushing with a Stellite faced roller in the bar in the main head. The same table speed and the same feed are used for the burnishing operation as are used in the second or finishing operation. The three operations of the first chucking may be performed on a bushing of this size in 6 min. elapsed time.

The second chucking on the same bushing consists

also of three operations, the first of which involves the rough facing of the top flange with the main head while rough turning the outside diameter of the same flange with the side head. For this roughing operation a table speed of 62 r.p.m. is used and a feed of .068 in. The

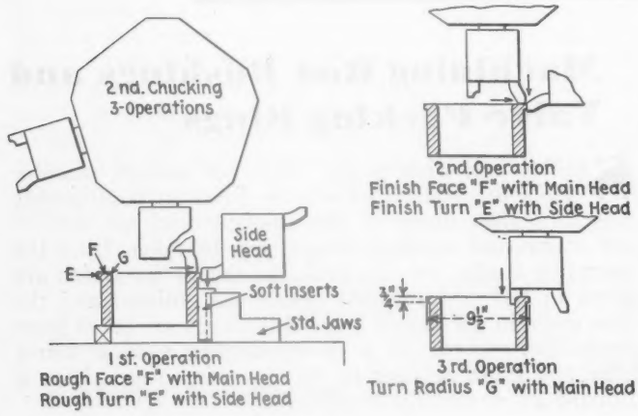


Fig. 2

second operation consists of the finish facing of the top of the flange with the main head while finish turning the outside diameter with the side head. These operations are shown as surfaces *E*, *F* and *G* in Fig. 2. For the second operation a table speed of 69.7 r.p.m. and a feed of .068 in. are used. The third and final operation of the second chucking is the finishing of the radius in the bore of the bushing with the main head which is performed at a table speed of 60.2 r.p.m. and a feed of .033 in. The time involved in the work in connection with the second chucking of this bushing is 4 min., making a total time for complete finishing of the bushing, floor to floor, 10 min., which includes setting up and removing the work from the table. The time given here is that for the finishing of a single bushing, and an average production of five pieces per hour should be maintained without difficulty, allowing for an average efficiency of operators of not over 85 per cent.

Machining Valve-Packing Rings

One of the most interesting machine-shop jobs on locomotive parts is machining packing rings. The operations described here are shown in Fig. 3 and the time given is in consideration of the use of multiple tools together with a ring-holding device to collect the rings after they are cut off. The entire finishing of these valve-packing rings from a packing tub 12⅞ in. outside diameter is performed at one chucking wherein the tub casting is held in a three-jaw chuck and the work is performed in four separate operations. The first operation consists of rough boring the full length of the utb with the main head of the machine, while at the same time the outside is rough-turned with a tool in the side head. On these operations a table speed of 22 r.p.m. is used with a feed of .056. The second operation consists of the finish boring of the full length of the tub with the main head and the rough recessing of 19 grooves for as many rings with a set of gang tools in the side head. A table speed of 16 r.p.m. is used for the second operation and the feed for the grooving tools is .007 in. The third operation consists of finishing the rough end of the tub for the first ring with the side head, for which a table speed of 22 r.p.m. and a feed of .113 in. is used. The fourth and final operation is the parting of the rings with the parting tool in the main head set by a micrometer dial. As each ring is cut off it is held in a special ring-holding device mounted on a swing bracket on the side head.

The entire time involved for setting up the packing tub, machining and removing the rings is 1 hr. 35 min. for the finishing of 19 rings, or an average of 5 min. per ring. The material used is cast iron.

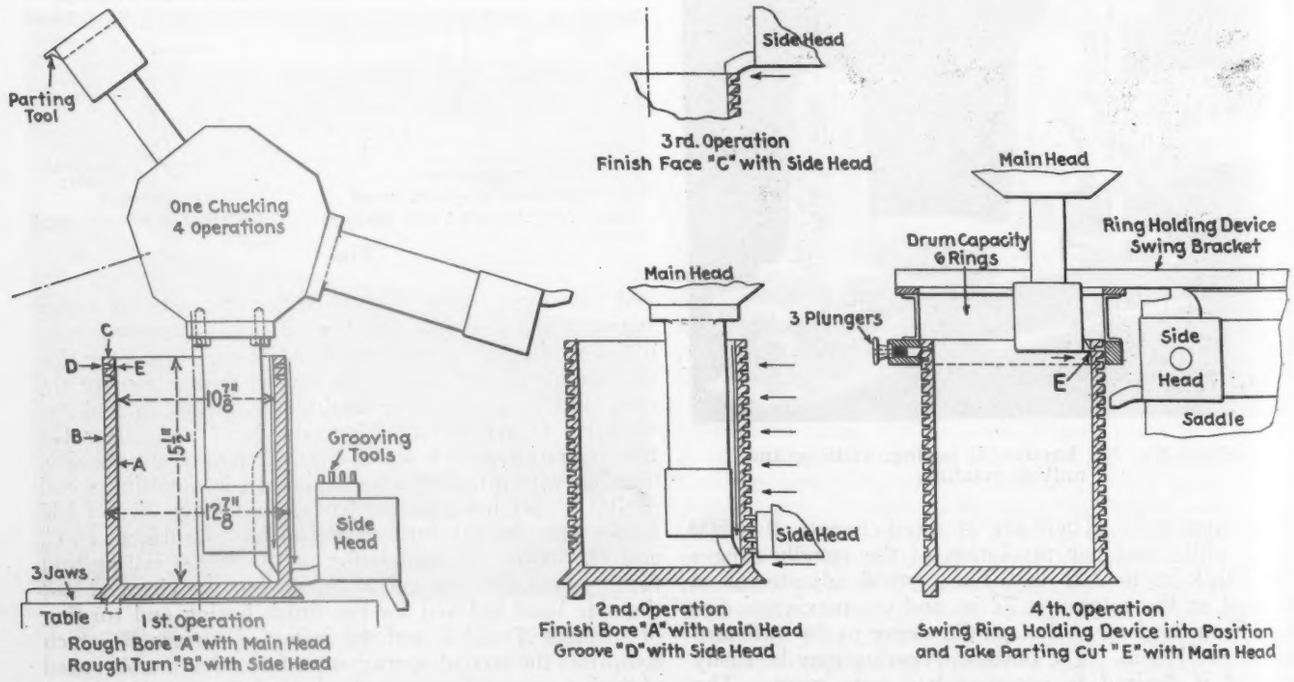


Fig. 3

Safety Tongs for Round Materials

A SPECIAL pair of tongs which have proved very satisfactory for handling piston rods, small axles, steel tubes and other round material is shown in the illustration, the construction being clearly indicated.

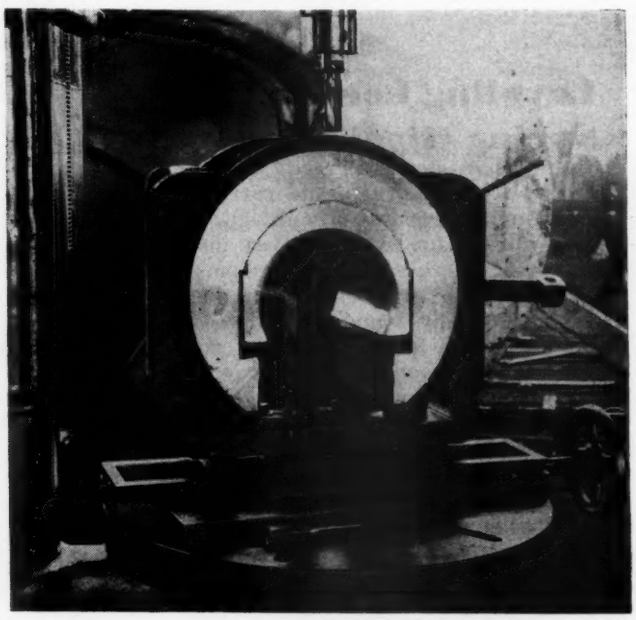
Safety tongs used in handling heavy round material with a minimum of chance of personal injury

Owing to the pointed and relatively thin construction of the tong jaws, they can be readily applied around the axles even when the latter are rolled closely together on the shop floor or storage rack. The action of the hoist on the double chain connected to the tong handles prevents any possibility of the axle dropping during the lifting operation or at any time while the weight of the axle is supported by the tongs. As a safety precaution against pinched fingers in handling these tongs, it will be noted that a metal stop is electric-welded to each handle in such a way as to prevent the tongs' closing beyond a certain point.

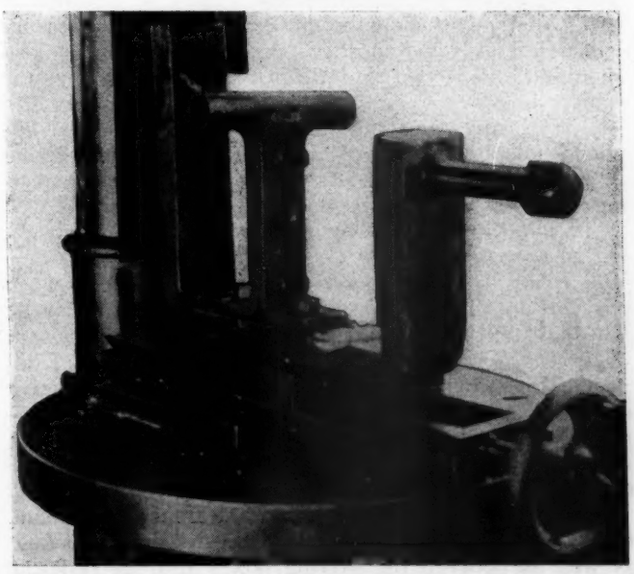
Milling Worn Driving-Box Saddle Seats

THE use of a convenient fixture and end mill for truing worn driving-box saddle seats is shown in the illustration. The fixture, which was developed in the Clinton (Iowa) shops of the Chicago & North Western, is applied to the table of a conventional drill press and used for refinishing saddle seats square with the shoe and wedgeways, square with the axis of the crown bearing and at a standard distance from the bearing center.

Worn saddle-bearing seats having been built-up by electric welding, the driving box is applied on the fixture, as shown in the illustration, and an end mill inserted in the drill press spindle. Cross feed is provided by means of an old planer crossbar, bolted to the center of the drill table. A heavy U-shaped frame, made of 2-in. by 5-in. steel, with the left leg 20 in. high and the right leg 14 in. high, is bolted to the tool post rest, being moved on the sliding ways of the crossbar by turning the feed screw. The two legs of the U-frame are spaced



Fixture for milling worn driving-box saddle seats on a drill press



View of the milling fixture before the driving box is put in place

20 in. apart to accommodate the larger size driving boxes and the right leg is drilled and tapped to accommodate a 2-in. V-thread screw.

The weight of the driving box is supported on a horizontal piece of 2-in. pipe, 12 in. long, welded to a double bar support bolted to the bottom of the U-frame. This holds the driving-box crown bearing parallel with the drill table and, when the 2-in. screw is tightened, the

box is forced against the longer leg of the U-frame, thereby holding the shoe and wedgeways accurately perpendicular. Operation of the end mill to machine the built-up seats for the driving-box saddles then produces true surfaces which are square with the shoe and wedgeways and with the bore of the crown bearings. The solid-flute end mill is 1¼ in. in diameter, and made of high-speed steel.

Leveling Locomotive Spring Rigging

WHEN the springs and carrying-gear of a locomotive are properly designed and applied, the rigging will remain level in service until some abnormal condition develops, such as worn pins and bushings, a collapsed spring, or a change in diameter of wheels. The fundamentally sound method to follow in leveling spring rigging is to determine, in each case, the cause of the abnormal condition which has thrown the rigging out of level and correct that condition, rather than to promiscuously shorten or lengthen spring hangers.

The first requisite of level springs and spring rigging is proper design of springs, equalizers, hangers, etc. In order to produce proper designs of these parts, the draftsman must know accurately the total spring-borne weight of the locomotive and the center of gravity of this weight. From this information he can determine the loads to be supported by each of the various springs and arrange the system of equalization accordingly.

Each spring should be tested before application to prove that it will stand at the specified height under the load to be carried, and this test should be repeated at each subsequent shopping of the locomotive. Springs which fail to stand at the specified height under load should be disbanded and the leaves retempered in the spring shop.

With springs and rigging properly designed and applied, the subsequent work of maintaining spring rigging in a level condition consists of singling out and correcting worn or defective conditions as they occur, as well as in compensating for changes in diameters of wheels, etc.

The best method of correcting conditions due to worn pins and bushings consists of renewing the defective parts. The best method of compensating for discrepancies in diameters of wheels, worn bearings, journals, etc., depends so much upon the construction of the locomotive that they can not be dealt with accurately in a broad general discussion of the subject. There are, however, a few fundamental rules which can be followed in practically all cases. These are:

(a) See that specified minimum clearances are maintained between frame rails and the tops of driving boxes, as well as between the driving boxes and the pedestal binders.

(b) The height of couplers and frames above top of rail should vary within the permissible limits according to the amount of wear on tires and wheels. The height of these parts should be the maximum only when wheels and tires are of full diameter. Do not try to maintain locomotive frames and couplers at maximum height from the rail under all conditions.

(c) Avoid, as far as possible, the use of thin tires or small diameter wheels on front or trailing trucks with full diameter tires on driving wheels, or vice versa. Unavoidable discrepancies in diameter between driving and truck wheels may be compensated for by various means without resorting to the lengthening or shortening of spring hangers in the blacksmith shop. The use of false spring seats under driving and trailer truck springs affords a convenient means for compensating for tires of reduced thickness. Liners inserted between male and female center plates of front trucks of the four-wheel type usually serve to compensate for reduced diameter truck wheels.

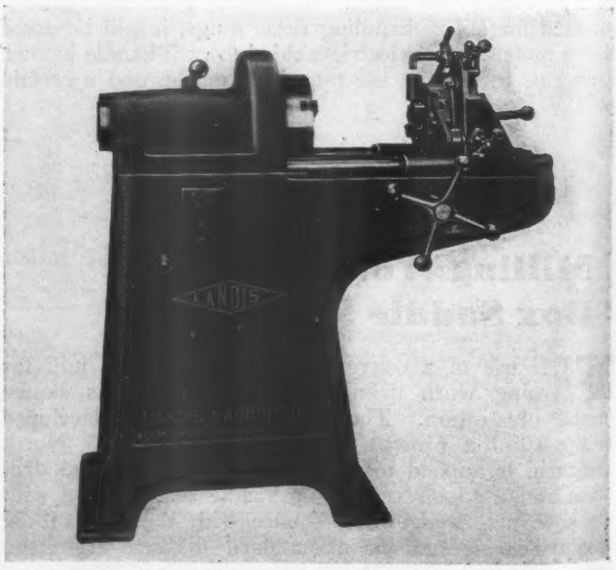
(d) When locomotives are shopped for repairs, adjustments should be made to compensate for worn conditions of axles, brasses, etc., whereby each spring seat will be carried at the specified level with respect to the plane of axle centers. These adjustments can usually be made to advantage by varying the height of driving spring saddles.

(e) When spring rigging gradually becomes cocked, due to wear on bushings, pins, hanger gibs, spring clips, etc., or to one or more weakened springs, the parts at fault should be renewed or properly repaired.

(f) Do not move equalizer fulcrum pins from their specified location or alter the length of equalizer arms. Changes of this nature disturb the distribution of weights and generally result in the overloading of certain springs and bearings. In order to avoid the possibility of mistakes of this nature, it is a good plan to plug up or blank all holes in equalizer fulcrum castings except those that are authorized for use.

Threading Machine for Maintenance Work

A NEW combination pipe and bolt threading machine, named the "Little Landis," has been brought out by the Landis Machine Company, Waynesboro, Pa. The machine is of the lathe type in which the work is revolved and is designed to thread, ream and cut off pipe and to thread bolts, rods, etc. It is



"Little Landis" combination pipe and bolt threading machine

designed for light weight, quick set-up changes and economical operation.

It is driven by a 1-hp. motor of the industrial type, the motor being mounted in an enclosed compartment in the bed and connected to the geared headstock by means of a silent chain drive. A one-piece box type head is employed. The gear box through which three changes of speed are available is cast integral with the spindle housing, thus affording rigidity. All gears are cut and run in an oil bath. The cross rail, which supports the die head and cutting-off and reaming tools, is integral with the carriage. The unit is of sturdy design and is centrally located on the carriage so as to minimize overhang. A scroll chuck of the three-jaw universal type is employed.

The Landis die heads are of new design, combining light weight, rigidity and strength. The heads are of the quick-opening type and have a universal adjustment for size, two die heads having a combined capacity ¼ in. to 2 in. being furnished as standard equipment. By applying bolt chaser holders the 2-in. head can be used for threading bolts from ⅜ in. to 1¼ in. The die heads are adjusted for diameter through a self-locking ratchet screw, the adjustment being universal and quickly made. The setting of the chasers in the holders remains constant for all diameters. The chasers used in the die heads are of the Landis tangential type and are of the same design as those employed in the standard line of machines.

Grinder Attachment For Planer

FOR flat surface-grinding operations, too limited in amount to justify the use of a modern, heavy-duty, single-purpose grinding machine, the attachment illustrated has been adapted for use on a standard planer, being readily applied or removed. The supporting steel framework and brackets, shown in the illustration, are bolted to the two crossfeeds of the planer. The three-horsepower, alternating-current, driving motor is rigidly bolted to one of the brackets and direct-connected through a flexible coupling to the grinding-wheel spindle, which operates in SKF roller bearings and is supported in a housing rigidly bolted to the horizontal supporting plate and crossfeed carriage.

Grinder attachment as applied to an old planer and used for relatively light work

The motor operates at a speed of 1,200 r.p.m., or the same as that of the grinding wheel which is 18 in. in diameter and has a 1½-in. face. Crossfeed of the carriage and grinding wheel is provided by hand, and fine hand adjustment of the vertical feed, to control the depth of cut, is obtained by means of a special fine-thread screw and lock nut, indicated at *A*. A slight change is also necessary in the gear drive of the planer table to give it the same feed forward and backward. A supply of cooling water is provided by means of the hose, illustrated, the stream of water being directed under the grinding wheel.

Pipe-Storage Rack

THE illustration shows a pipe-storage rack which not only provides a convenient and safe storage for pipe of all commonly used sizes, but keeps this pipe off the floor and contributes substantially to the neat appearance of the shop.

The rack consists of four 5-in. steel angles, bolted to the shop wall to serve as vertical supports for the ½-in. by 2¼-in. steel horizontal bars or arms which carry the pipe. These arms, 28 in. long and spaced 11 in. on centers vertically, are forged with the outer end turned up 4 in. to prevent pipe from rolling from the rack, and with the back ends turned down 8 in. in order to provide a rigid, well-braced means of bolting to the upright angles. The rack, itself, is 15 ft. long and provided with four series of horizontal supporting arms. The lower section of the rack is equipped with a 12-gage sheet steel tray to serve as a suitable means for storing short lengths of pipe. The upper outside edge of this tray is turned over slightly as a safety measure.

Pipe-storage rack

Among the Clubs and Associations

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.—The annual outing of the Southern and Southwestern Railway Club will be held at Jacksonville, Fla., September 20 and 21.

POWER AND MECHANICAL ENGINEERING.—The Eleventh National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace, New York, December 3 to 8.

CAR FOREMEN'S ASSOCIATION OF CHICAGO.—W. J. Patterson, director, Bureau of Safety, I. C. C., will present a paper on the Activities of the Bureau of Safety at the meeting of the Car Foremen's Association of Chicago to be held on September 10 at 8 p. m. at the LaSalle Hotel, Chicago.

NORTHWEST CAR MEN'S ASSOCIATION.—F. C. Hasse, general manager of the Oxweld Railroad Service Company, will present a paper, accompanied by motion pictures, at the September 10 meeting of the Northwest Car Men's Association which will be held at 8 p. m. at the Minnesota Transfer Y. M. C. A. Building, St. Paul, Minn.

FUEL ASSOCIATION.—The International Railway Fuel Association, with the cooperation and approval of the American Railway Association, has arranged to hold a two-day meeting at the Hotel Sherman, Chicago, on September 17 and 18. The meeting will mark the twenty-sixth year of the association's work on railway fuel and will be the first meeting held by the association in three years, during which important fuel developments have arisen, including increases in fuel costs. The meeting will be addressed by a leading executive of the coal industry, a prominent railway mechanical officer and a representative of the federal co-ordinator, and the program will also include reports of standing committees, as follows:

Front Ends, Grates and Ash Pans
Fuel Distribution and Statistics
Fuel Stations
Inspection and Preparation of Coal
Locomotive Firing Practice—Coal
Locomotive Firing Practice—Oil
New Locomotive Fuel Economy Devices
Steam Turbine and Steam Condensing Locomotives
Storage—Coal
Storage—Oil
Stationary Boiler Plants—Coal
Stationary Boiler Plants—Oil

AMERICAN WELDING SOCIETY.—The fourteenth fall meeting of the American Welding Society will be held at the Hotel New Yorker, New York, October 1 to 5, inclusive. Among the many papers on the tentative program for this meeting are the following three which would appear to be particularly outstanding because of the interest being displayed by the railroads in the use of light-weight steels in passenger car construction: Welding of Cromansil Steel, by H. M. Boylston, Case School of Applied Science; Corrision Fatigue of Welded Stainless Steels, by Wilber E. Harvey, Lehigh University, and Technical Phases of Application of Welding in Hi-Tensile Division of E. G. Budd Manufacturing Company, by M. B. Butler.

WESTERN RAILWAY CLUB.—After a successful season's program of technical papers and addresses, in the course of which its membership has been built up to a total of more than 1,500 railway officers and supply company representatives, the Western Railway Club plans to hold its first annual outing and golf party on September 10 at the Olympia Fields Country Club, Chicago. The entire day will be devoted to a series of games and recreation, including golf, tennis, bridge, etc., with prizes of *all* kinds offered for *all* kinds of players. Dinner in the evening will be followed by a special entertainment, the entire program being designed to afford members and guests a maximum opportunity to fraternize and become better acquainted.

Directory

The following list gives names of Secretaries, dates of next regular meetings and places of meeting of mechanical associations and railroad clubs:

AIR-BRAKE ASSOCIATION.—T. L. Burton, c/o Westinghouse Air Brake Company, Thirty-fourth floor, Empire State Bldg., New York.

ALLIED RAILWAY SUPPLY ASSOCIATION.—F. W. Venton, Crane Company, Chicago.

AMERICAN RAILWAY ASSOCIATION.—Division V.—MECHANICAL.—V. R. Hawthorne, 59 East Van Buren street, Chicago.

DIVISION V.—EQUIPMENT PAINTING SECTION.—V. R. Hawthorne, Chicago.

DIVISION VI.—PURCHASE AND STORES.—W. J. Farrell, 30 Vesey street, New York.

DIVISION I.—SAFETY SECTION.—J. C. Caviston, 30 Vesey street, New York.

DIVISION VIII.—CAR SERVICE DIVISION.—C. A. Buch, Seventeenth and H streets, N. W., Washington, D. C.

AMERICAN RAILWAY TOOL FOREMEN'S ASSOCIATION.—G. G. Macina, 11402 Calumet avenue, Chicago.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Calvin W. Rice, 29 W. Thirty-ninth street, New York.

RAILROAD DIVISION.—Marion B. Richardson, Room 332, 30 Church street, New York.

MACHINE SHOP PRACTICE DIVISION.—R. E. W. Harrison, 6373 Beechmont avenue, Mt. Washington, Cincinnati, Ohio.

MATERIALS HANDLING DIVISION.—M. W. Potts, Alvey-Ferguson Company, 1440 Broadway, New York.

OIL AND GAS POWER DIVISION.—Edgar J. Kates, 1350 Broadway, New York.

FUELS DIVISION.—W. G. Christy, Department of Health Regulation, Court House, Jersey City, N. J.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.—Jos. A. Andreucetti, C. & N. W., 1519 Daily News Building, 400 W. Madison St., Chicago, Ill. Annual meeting, October 4-5, 1934, Hotel Sherman, Chicago, Ill. Exhibit by Railway Electrical Supply Manufacturers' Association.

CANADIAN RAILWAY CLUB.—C. R. Crook, 2276 Wilson avenue, Montreal, Que. Regular meetings, second Monday of each month except in June, July and August at Windsor Hotel, Montreal, Que.

CAR DEPARTMENT OFFICERS ASSOCIATION.—A. S. Sternberg, master car builder, Belt Railway of Chicago, 7926 South Morgan street, Chicago.

CAR FOREMEN'S ASSOCIATION OF CHICAGO.—G. K. Oliver, 2514 West Fifty-fifth street, Chicago. Regular meetings, second Monday in each month except June, July and August, La Salle Hotel, Chicago, Ill.

CAR FOREMEN'S ASSOCIATION OF OMAHA, Council Bluffs and South Omaha Interchange.—Geo. Kriegler, car foreman, Chicago, Burlington & Quincy, Sixteenth avenue and Sixth street, Council Bluffs, Iowa. Regular meetings, second Tuesday of each month at Council Bluffs.

CENTRAL RAILWAY CLUB OF BUFFALO.—M. D. Reed, Room 1817, Hotel Statler, Buffalo, N. Y. Regular meeting, second Thursday each month except June, July and August, at Hotel Statler, Buffalo.

EASTERN CAR FOREMEN'S ASSOCIATION.—E. L. Brown, care of the Baltimore & Ohio, Staten Island, N. Y. Regular meetings, fourth Friday of each month, except June, July, August and September.

INDIANAPOLIS CAR INSPECTION ASSOCIATION.—R. A. Singleton, 822 Big Four building, Indianapolis, Ind. Regular meetings first Monday of each month, except July, August and September, at Hotel Severin, Indianapolis, at 7 p. m. Noon-day luncheon, 12:15 p. m. for Executive Committee and men interested in the car department.

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION.—W. J. Mayer, Michigan Central, 2347 Clark avenue, Detroit, Mich.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.—T. D. Smith, 1660 Old Colony building, Chicago.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION.—William Hall, 1061 W. Wabasha street, Winona, Minn.

MASTER BOILERMAKERS' ASSOCIATION.—A. F. Stiglmeier, secretary, 29 Parkwood street, Albany, N. Y.

NEW ENGLAND RAILROAD CLUB.—W. E. Cade, Jr., 683 Atlantic avenue, Boston, Mass. Regular meeting, second Tuesday in each month, excepting June, July, August and September.

NEW YORK RAILROAD CLUB.—D. W. Pye, Room 527, 30 Church street, New York. Meetings, third Friday in each month, except June, July and August, at 29 West Thirty-ninth street, New York.

NORTHWEST CAR MEN'S ASSOCIATION.—E. N. Myers, chief interchange inspector, Minnesota Transfer Railway, St. Paul, Minn. Meeting first Monday each month, except June, July and August, at Minnesota Transfer Y. M. C. A. Gymnasium building, St. Paul.

PACIFIC RAILWAY CLUB.—William S. Wollner, P. O. Box 3275, San Francisco, Cal. Regular meetings, second Thursday of each month in San Francisco and Oakland, Cal., alternately.

RAILWAY CAR MEN'S CLUB OF PEORIA AND PEKIN.—C. L. Roberts, R. F. D. 5, Peoria, Ill.

RAILWAY CLUB OF GREENVILLE.—Ralph D. Stewart, 21 Sherrard avenue, Greenville, Pa. Regular meeting third Thursday in month, except June, July and August.

RAILWAY CLUB OF PITTSBURGH.—J. D. Conway, 1941 Oliver building, Pittsburgh, Pa. Regular meeting fourth Thursday in month, except June, July and August, Ft. Pitt Hotel, Pittsburgh, Pa.

RAILWAY FIRE PROTECTION ASSOCIATION.—R. R. Hackett, Baltimore & Ohio, Baltimore, Md. Annual meeting October 16-18, Congress Hotel, Chicago.

RAILWAY SUPPLY MANUFACTURERS' ASSOCIATION.—J. D. Conway, 1841 Oliver building, Pittsburgh, Pa. Meets with Mechanical Division and Purchases and Stores Division, American Railway Association.

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.—A. T. Miller, P. O. Box 1205, Atlanta, Ga. Regular meetings third Thursday in January, March, May, July and September. Annual meeting, third Thursday in November, Ansley Hotel, Atlanta, Ga.

SUPPLY MEN'S ASSOCIATION.—E. H. Hancock, treasurer, Louisville Varnish Company, Louisville, Ky. Meets with Equipment Painting Section, Mechanical Division American Railway Association.

TORONTO RAILWAY CLUB.—N. A. Walford, district supervisor car service, Canadian National, Toronto, Ont. Meetings first Friday of each month except June, July, August and September.

TRAVELING ENGINEER'S ASSOCIATION.—W. O. Thompson, 1177 East Ninety-eighth street, Cleveland, Ohio.

WESTERN RAILWAY CLUB.—C. L. Emerson, 822 Straus building, Chicago. Regular meetings third Monday in each month except June, July, August and September.

NEWS

THE SEABOARD AIR LINE has awarded a contract to the Ross & White Company, Chicago, for the construction of a fireproof, overhead storage, automatic electric locomotive coaling and sanding plant at Elberton, Ga. The plant is designed to supply coal and sand and remove cinders from locomotives with one stop of the engine.

THE TIMKEN ROLLER BEARING COMPANY has received an order for bearings and boxes for the 25 new baggage cars which the Chicago, Milwaukee, St. Paul & Pacific will build in its shops at Milwaukee, Wis. The J. G. Brill Company, Philadelphia, Pa., has placed with the Timken Company an order for boxes and bearings to be used on four rail motor cars which it is building for the Uruguayan State Railways.

Car on Repair Track Legally Not in Use

A CAR WHICH has reached the repair track for repairs is not "in use" within the Safety Appliance Act. It is out of service and the railroad can take off a handhold or any other safety appliance necessary to effect the repairs without violating the act. The Circuit Court of Appeals, Seventh Circuit, in an action by J. K. Kelley against the New York, Chicago & St. Louis, holds that a field brakeman who was injured by falling from such a car because of the removal of a grab-iron could not recover under the act.

Katy Dismantling 4,551 Cars and Engines

THIS YEAR'S dismantling program of the Missouri-Kansas-Texas, now under way, calls for the dismantling of 4,551 pieces of equipment and the salvaging of more than 60,000 tons of scrap material. The program, begun on April 30, calls for the dismantling of 2,012 coal, 985 stock, 510 automobile, 489 box, 307 ballast and 103 outfit cars, 52 locomotives, 80 passenger cars, including 2 business cars and 13 miscellaneous cars. More than a third of the work has been done, 1,672 pieces of equipment having been dismantled as of July 31. The work is proceeding at the rate of about 15 cars a day.

Railroads Must Bulletin New Labor Law

THE NATIONAL MEDIATION BOARD has issued a general order to the railroads requiring them to post on bulletin boards a notice stating that all disputes between the carriers and their employees will be handled in accordance with the railway labor act and that stated paragraphs of section 2 of the law as amended at the last session of Congress are by law made a part of each contract between carriers and their employees and shall be held binding regardless of any express or implied agreements to the contrary. The paragraphs required to be quoted in the notices are those that representatives shall be designated by the respective parties without influence, interference, or coercion; that employees shall have the right to bargain collectively through representatives of their own choosing; that a majority of any craft or class of employees shall have the right to determine who shall be its representative; and that no carrier shall require any person seeking employment to promise to join or not to join a labor organization, etc.

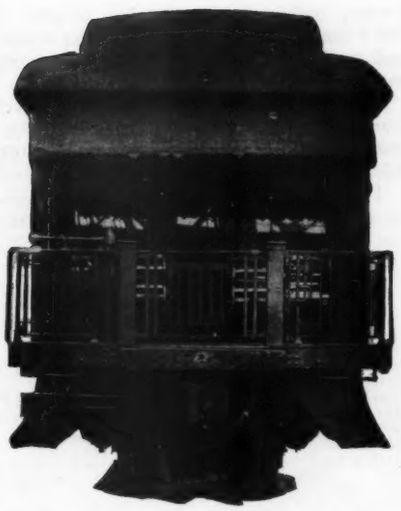
"Railplane" Exhibited at Washington

A DEMONSTRATION of a new system of transportation, known as the "Railplane," was given at Washington, D. C., on August 3. The system was developed in Scotland and the model recently brought to the United States by Alexandre Djakeli of Brussels, who controls the rights and who has granted to J. Carson Adkerson authority to present it to the United States.

The system consists of a single overhead carrier rail from which a streamline car is slung on the traveling trucks. A second rail runs beneath the center of the car for the purpose of limiting the sway of the car and for controlling it on curves. The car is driven by means of air propellers and the system is provided with equipment for signaling, lighting, power distribution and safety devices. The system is proposed to be used independently or in connection with existing railways for high-speed passenger service. The Railplane, it was claimed, will make speeds of from 200 to 300 m.p.h. with safety and comfort at an operating cost of less than 10 per cent of present railway transportation. A short full-sized operating line has been installed at Milngavie, Scotland, for experimental purposes.

Faster Trains Planned Chicago to Twin Cities

THE CHICAGO, BURLINGTON & QUINCY, the Chicago & North Western and the Chicago, Milwaukee, St. Paul & Pacific are planning substantial reduction in the schedules of passenger trains operated between Chicago and the Twin Cities. While the plans are still indefinite, the reductions will range from two to four hours and thus place some trains on 6½ hr. and 9 hr. schedules, as compared with the present schedules which range from 10 hr. 30 min., to 13 hr. 15 min. for route distances ranging from 407 to 431 miles. Part of the program involves the operation of two streamlined, three-car articulated trains by the C. B. & Q. Two such trains, similar to the Zephyr, have been ordered from the J. G. Brill Company, as noted in the New Equipment table elsewhere on this page.



To confirm the feasibility of a 6½ hr. schedule for these trains, the Burlington on July 30 operated its Zephyr from Chicoga to St. Paul, 431 miles, in 6 hr. 4 min., including 6 stops of 1 min. standing time each. Returning, the distance was covered in 6 hr. 10 min., more time being taken for stops. The schedule in detail was as follows:

		Miles	
Left	Chicago	...	9:30 A.M.
Arrived	Aurora	38	10:03 A.M.
"	Savanna	145	11:32 A.M.
"	E. Dubuque	185	12:08 P.M.
"	Prairie du Chien	239	12:52 P.M.
"	LaCrosse	298	1:39 P.M.
"	E. Winona	326	2:00 P.M.
"	St. Paul	431	3:34 P.M.

Average 71 m.p.h.

Chicago-Milwaukee Train Averages 76 M. P. H. Between Terminals

A REGULAR Milwaukee express of the Chicago, Milwaukee, St. Paul & Pacific made the 85-mile run from Chicago to Milwaukee, Wis., in 67 min. 35 sec. on Friday, July 20. The run was made by a standard schedule train, one of the fleet which recently inaugurated a 90-min. service between Chicago and Milwaukee, and by the engine crew which handles the train each day. The train consisted of the following cars:

	Weight, tons
Baggage car	68.6
Parlor car	83.1
Coach	75.8
Coach	72.9
Business car	88.1

The locomotive—a 4-6-4 type with 26-in. by 28-in. cylinders and a tractive force of 45,882—weighed 653,650 lb. with its

tender, making a total train weight of 388.5 tons. All of the cars and the tender and trailer trucks of the locomotive were equipped with Timken roller bearings.

The run was made over relatively level track with few curves. Curves of 1 deg. were negotiated at 102 m.p.h. with little discomfort in the rear car.

The train left Chicago at 9 a.m. and arrived in Milwaukee at 10:07:35 a.m., the run in detail being as follows:

Stations	Distance, miles from Chicago	Distance, increment, miles	Time increment, min.	Time increment, sec.	Speed between stations, m.p.h.
Chicago					
Western ave. ..	2.9	2.9	6	35	26.4
Pacific Junction	5.4	2.5	3	02	49.3
Healy	6.4	1.0	0	51	69.9
Grayland	8.2	1.8	1	33	69.15
Mayfair	9.0	0.8	0	49	58.0
Forest Glen ...	10.2	1.2	1	08	63.0
Edgebrook	11.3	2.1	1	52	67.0
Morton Grove..	14.3	2.0	1	20	89.6
Golf	16.2	1.9	1	11	96.0
Glenview	17.4	1.2	0	50	96.6
Techny	20.2	2.8	2	06	80.0
Northbrook	20.9	0.7	0	31	80.3
Deerfield	23.9	3.0	2	05	86.4
W. Lake Forest	28.0	4.1	2	36	94.4
Rondout	32.3	4.3	2	41	95.7
Wilson	36.8	4.5	2	58	90.9
Gurnee	38.6	1.8	1	14	86.8
Wadsworth	42.9	4.18	2	34	97.44
Russell	47.0	4.1	2	39	94.5
Ranney	51.6	4.6	2	57	93.2
Truesdell	52.6	1.0	0	45	79.2
Somers	57.5	4.9	3	18	88.8
Sturtevant	61.8	4.3	2	58	86.5
Franksville	66.0	4.2	2	46	90.8
Caledonia	69.4	3.4	2	13	91.8
Oakwood	72.8	3.38	2	04	97.97
Lake	77.9	5.1	3	12	95.5
National ave...	84.1	6.2	5	58	62.1
Milwaukee	85.0	0.9	2	49	19.0

The highest speed attained was between Oakwood and Lake when the speedometer registered 103.5 m.p.h. Various sustained speeds on the run were:

	Distance, miles	Time, min.	Time, sec.	Speed, m.p.h.
Chicago to Milwaukee..	85.7	67	35	76.07
Mayfair to Lake	68.9	45	58	89.92
Edgebrook to Oakwood..	61.4	39	46	92.62
Caledonia to Oakwood..	3.38	2	4	97.97
Gurnee to Wadsworth...	4.18	2	34	97.44

National Board of Adjustment Formed

FORMATIVE meetings of the National Railroad Adjustment Board, created by the bill to amend the Railway Labor Act, which bill was passed as one of the final measures of the last Congress on June 18, were held in Chicago on July 30 and 31. These meetings were for the purpose of confirming the personnel of the board and to establish the organization and prepare for its early functioning.

The board will operate under four divisions, each more or less of an individual unit, but all with headquarters in Chicago and under the same general supervision. Division 1 will handle train and engine service matters, Division 2 has supervision over shopcraft matters, Division 3 will devote its attention to clerks, maintenance of way, signalmen, telegraphers and dispatchers, and Division 4 will handle matters pertaining to railway employees engaged in marine service.

The railway personnel of Divisions 1, 2 and 3 will consist of two representatives each from the Eastern and Western lines, and one from the Southeastern lines, while Division 4 will have one representative from each of the three regions.

The appointments to Division 2, together with the positions last held, are as follows:

Western Lines: J. A. Anderson, Master Mechanic, C. M. St. P. & P.; C. E. Peck, superintendent of shops, O.-W. R. R. & N.

Southeastern Lines: George H. Dugan, vice-president (Subsidiary Lines), Southern.

Eastern Lines: M. W. Hassett, assistant superintendent equipment, N. Y. C.; A. G. Walther, assistant supervisor of shops, B. & O.

Brotherhoods: Harry J. Carr, general vice-president, Intl. Assn. of Machinists; George Wright, international representative, Intl. B. of B., D. F. & H.; F. H. Knight, assistant general president, B. of R. R. Carmen of America; Chas. J. McGowan, international representative, Intl. B. of B., I. S. B. and H. of America; L. M. Wicklein, general vice-president, S. M. W. I. Assn.

Nearing Half-Way Mark on P. R. R. Improvements

NEARING THE halfway mark on its extensive electrification improvemnt and equipment building program, financed by P. W. A., the Pennsylvania announced on August 17 that more than 12,000 furloughed railroad men are working directly on the project, with weekly payrolls running around $300,000. Orders for materials and supplies for the job already placed in American markets approximate $23,500,000.

It is estimated by railroad and government officials that at least 25,000 men have been given employment on the railroad and in industry as a result of the improvement work.

In the railroad's shops at Harrisburg, Altoona and Pittsburgh, on the fabrication and erection of 7,000 new freight cars under construction by the railroad as a part of the general P. W. A. improvement program, at a peak 2,501 men were employed. The present weekly payroll is $60,000. Of the total order 4,972 cars have been completed. More than 147,000 tons of steel and 16,600,000 feet of lumber are required for the car construction project.

Hundreds of additional men are engaged in the construction of 28 electric passenger locomotives for service on the New York-Washington line, both in the Altoona Shops of the railroad, where eleven of these engines are being assembled, and in the plants of the electrical companies. Work is also going forward on fifteen switching engines for the new line.

New Equipment

CAR ORDERS

Road	No. of cars	Type of car	Builder
C. B. & Q.	2[1]	3-car articulated trains	Edw. G. Budd Mfg. Co.
General American Trans. Co.	5[2]	60-ton Dry-Flo tank	Own shops
G. M. & N.	2[3]	3-car non-artic. trains	American Car & Fdry. Co.
	1[3]	Streamlined coach	American Car & Fdry. Co.
Hooker Electrochemical Co.	4	30-ton tank	American Car & Fdry. Co.
	4	30-ton tank	General American Tank Car Corp
Seaboard Air Line	100	70-ton phosphate	Pullman Car & Mfg. Corp.

CAR INQUIRIES

Woodward Iron Co.	60	50-ton ore	.....

LOCOMOTIVE ORDERS

Road	No. of locos.	Type of locomotive	Builder
Seaboard Air Line	5[4]	2-6-6-4	Baldwin Loco. Wks.

LOCOMOTIVE INQUIRIES

Illinois Central	11[5]	Diesel	.....
Pittsburg, Shawmut & Northern	2	2-6-6-4	.....

[1] These two additional high-speed, streamlined, three-car articulated trains will be similar to the "Zephyr," but will not carry mail, the additional space gained through the elimination of the mail compartments being given over to the accommodation of additional passengers. Other changes will be principally of a minor character. The trains are to be placed in regular daylight service between Chicago and Minneapolis-St. Paul, Minn., between which points they will operate in opposite directions daily.

[2] To be leased to B. J. Babbitt Co., Albany, N. Y., for transporting silica sand.

[3] These cars, seven in all, are to be fully streamlined and of the non-articulated type. A lightweight alloy steel, U. S. S. Cor-Ten, will be used. The entrance and exit will be in the center, rather than at the end as in conventional standard equipment. Closures between the cars will be flush with the outer contours of the cars to obtain the proper streamlined effect. The first car, comprising the power unit, will have a 600-hp. Diesel-electric engine and mail and baggage compartments. The center coach will contain a passenger compartment and a buffet kitchen, from which meals will be served throughout the train. The third car will be a sleeper-observation car, providing a stateroom and six upper and six lower berths. The rear end of this car will be an observation chair compartment. The cars will be completely air-conditioned, and indirect lighting will be featured throughout.

[4] This is a conditional order.

[5] To be purchased with P. W. A. allotment. The locomotives will be for switching service.

Supply Trade Notes

THE STANDARD CAR TRUCK COMPANY, Chicago, has been appointed exclusive sales representative of the insulation division of the Luse-Stevenson Company, Chicago.

THE HAROLD E. TRENT COMPANY, manufacturers of electric heating units and electric furnaces, has opened an office at 143 Liberty street, New York, in charge of A. H. Gurtner.

L. F. DUFFY, associated with the Chicago office of the Chicago Pneumatic Tool Company, railroad division, for six years, has been transferred to the St. Louis, Mo., office, 1931 Washington avenue.

THE VILOCO RAILWAY MACHINE COMPANY and the Viloco Railway Equipment Company, Chicago, have taken over the manufacture and sale of the Whelan bi-pass valve, following the death of Eugene B. Whelan.

THE BUHL SONS COMPANY, Detroit, Mich., has been appointed distributors of Toncan iron by the Republic Steel Corporation, Youngstown, Ohio.

JOHN RANDOLPH & SON, McCormick building, Chicago, have been appointed agents with territory from Chicago to the Pacific Coast, for the Apex Tool & Cutter Company, Inc., Shelton, Conn.

RALPH C. HARDEN has been appointed manager of packing sales in the Mechanical Goods division of the United States Rubber Company. He will be located at the company's main offices, 1790 Broadway, New York City. Mr. Harden during the last 15 years has held several positions with the Johns-Manville Sales Corporation, the latest of which was western regional vice-

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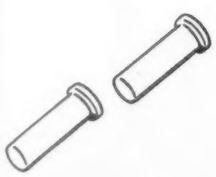
REPAIR THE OLD LOCOMOTIVES WITH MODERN MATERIALS



Toncan Iron Boiler Tubes Pipe Plates Culverts Rivets Tender Plates and Firebox Sheets • Sheets and Strip for special railroad purposes • Agathon Alloy Steels for Locomotive Parts • Agathon Engine Bolt Steel • Agathon Iron for pins and bushings • Agathon Staybolt Iron • Climax Steel Staybolts • Upson Bolts and Nuts • Track Material, Maney Guard Rail Assemblies • Enduro Stainless Steel for dining car equipment, for refrigeration cars and for firebox sheets • Agathon Nickel Forging Steel... The Birdsboro Steel Foundry & Machine Company of Birdsboro, Pa. has manufactured and is prepared to supply under license, Toncan Copper Molybdenum Iron castings for locomotives

Many locomotives built years ago are now in the shops preparing for future service. » » » Modernize them at least to the extent of using longer life, up-to-date materials. » » » Use Agathon Staybolts with their superior toughness and shock resistance; Toncan Iron firebox sheets that resist corrosion and have excellent fatigue resistance. For case-hardened parts select Agathon Nickel Iron, a material with a tough core as well as a hardened surface. » » » These are but a few of the many possible applications of alloy materials for equipment repairs. These and many more will reduce future locomotive repairs and delays in service. » » » Consult Republic concerning modern materials and spend your maintenance money most effectively.

CENTRAL ALLOY DIVISION, MASSILLON, OHIO

AGATHON NICKEL IRON

REPUBLIC STEEL CORPORATION

GENERAL OFFICES YOUNGSTOWN, OHIO

TONCAN IRON

president of sales, with headquarters at Chicago.

M. J. CZARNIECKI, general manager of sales of the A. M. Byers Company, Pittsburgh, Pa., has been elected vice-president in charge of sales, succeeding H. W. Rinearson, who has resigned. Mr.

M. J. Czarniecki

Czarniecki entered the sales organization of the Byers Company in 1913. The following year he was assigned to the New York office where he remained until his transfer in 1915 to Chicago. After the war, in 1918, he returned to Chicago as district manager and the following year was transferred to New York, serving as district manager until 1925 when he was appointed assistant general manager of sales, with headquarters at Pittsburgh, Pa. In September, 1930, Mr. Czarniecki was appointed to the newly created position of manager of tubular sales and subsequently was appointed general manager of sales.

ROBERT D. BARTLETT has been appointed general manager of the Franklin Steel Works, Chicago, a subsidiary of the Chicago Railway Equipment Company. Mr.

Robert D. Bartlett

Bartlett is a graduate of the law department of the University of Michigan (1907) and was admitted to the bar in Illinois in 1908. For 10 years he was identified with the New York Central Lines and the United States Railroad Administration in legal and operating capacities. In 1920 he became general manager of the Empire Freight Car Company, Kankakee, Ill., and from 1923 to 1931 was successively secretary and treasurer, assistant to the president and vice-president of the Ryan Car Company, Chicago.

WILLIAM MILLER, senior vice-president of the Pyle-National Company, Chicago, has been elected president to succeed Lawrence H. Vilas who died on July 22. Mr. Miller was born in Hannibal, Mo., on July 3, 1867, and began his railroad career as an apprentice in the Hannibal shops of the C. B. & Q. in June, 1882. In 1885 he served as a journeyman on the M.-K.-T., in 1886 on the Wabash, and in 1887 on the D. & R. G. W. In 1889 he was appointed foreman of shops of the St. Louis-San Francisco, and in 1900 became general foreman of the Colorado Midland. He held

William Miller

the latter position until 1904 when he became master mechanic of the Terminal Railroad Association and the Wiggins Ferry railroad of St. Louis. In 1905 he returned to the D. & R. G. W. as master mechanic and assistant superintendent, and in 1907 was appointed superintendent of motive power of the Western Maryland. In 1908 he left railroad service to become vice-president of the Adreon Manufacturing Company, which position he held until 1910 when he was elected president of the Monarch Pneumatic Tool Company and vice-president of the Standard Railway Equipment Company. He resigned from these positions in 1913 to become vice-president of the Pyle-National Company, and in 1914 was elected senior vice-president.

ANDREW D. HUNT recently resumed his duties as manager of engineering of the South Philadelphia (Pa.) Works of the Westinghouse Electric & Manufacturing Company. Mr. Hunt was appointed to this position in 1926 but in June, 1931, was temporarily transferred to the Chicago office of the company to act as steam specialist for the northwestern district. In October, 1932, he was recalled to the South Philadelphia Works, to serve again as steam service manager, which position he had previously held from 1920 until his appointment in 1926 as manager of engineering.

A. E. AINLAY, formerly sales manager of the Midwest Locomotive Works, Hamilton, Ohio, has been appointed sales manager of the newly created locomotive division of the Cummins Engine Company, with headquarters at Columbus, Ind. Mr. Ainlay's engineering experience began in April, 1910, with the Watson Machine Company, Paterson, N. J., and in 1915 he entered the engineering and sales departments of the Bethlehem Steel Company, remaining with that company until 1918.

A. E. Ainlay

The next six years were spent in the engineering departments of the Westinghouse Electric & Manufacturing Company, the Carnegie Steel Company and the Jeffrey Manufacturing Company. In August, 1923, he entered the locomotive field as assistant chief engineer of the Plymouth Locomotive Works, Plymouth, Ohio, later becoming sales manager of that company. In 1930, he went to the Midwest Locomotive Works in charge of sales and engineering.

HERBERT A. MAY, who recently resigned as assistant to the president of the Westinghouse Electric & Manufacturing Company, has been appointed vice-president of

Herbert A. May

the Safety Car Heating & Lighting Company and will have his headquarters in the Gulf building, Pittsburgh, Pa. Mr. May is a director of a number of other industrial companies.

Obituary

GEORGE E. MOLLESON, for many years in the railway supply business at New York, died suddenly on August 14, in the Hotel Earle, New York, at the age of 75.

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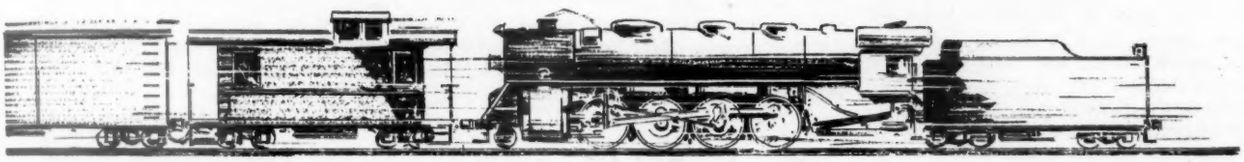
Quit Dragging

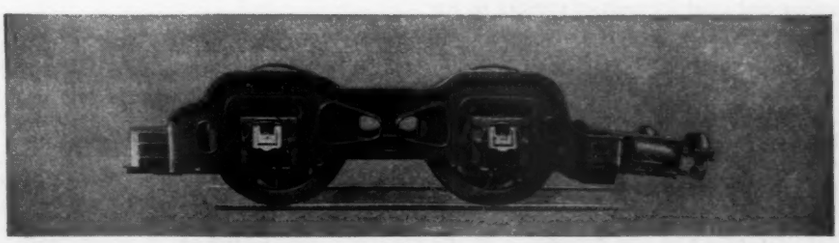
A PUSHER LOCOMOTIVE



Over Every Run

Use of The Locomotive Booster to start the train, and to help over the hard pulls, avoids the need of a lot of excess locomotive weight to be hauled around perhaps 80% of the time, when it is only needed for short periods. The Booster furnishes the extra tractive effort when needed.

Avoiding the need of hauling this excess weight over the road saves a great deal of wear on locomotive parts and saves many maintenance and fuel dollars.



Because material and tolerances are just right for the job, genuine Franklin repair parts give maximum service life.

FRANKLIN RAILWAY SUPPLY COMPANY, INC.

NEW YORK CHICAGO MONTREAL

Personal Mention

General

J. J. PRENDERGAST, acting mechanical superintendent of the Texas & Pacific, has been appointed mechanical superintendent, with headquarters at Dallas, Tex.

C. F. PARSONS, master mechanic for the New York Central with headquarters at Albany, N. Y., has been appointed assistant superintendent of equipment at New York.

H. C. TREXLER, who has been appointed superintendent of motive power of the Southern, with headquarters at Charlotte, N. C., was born on January 3, 1894, at Rowan County, N. C. He was educated in the public schools and entered railway service in August, 1909, as a machinist apprentice in the Spencer (N. C.) shops of the Southern. He became a machinist in 1913 and in 1919 machinist and erecting shop foreman at Spencer. Mr. Trexler was appointed shop superintendent in 1924, and in November, 1926, master mechanic at Somerset, Ky. In March, 1932, Mr. Trexler became master mechanic at Spencer, from which point he was transferred to Charlotte as superintendent of motive power.

Master Mechanics and Road Foreman

A. D. BINGMAN has been appointed master mechanic for the New York Central with headquarters at Albany, N. Y.

I. L. WAGNER has been appointed assistant road foreman of engines of the Philadelphia division of the Pennsylvania.

H. C. VINSANT, district foreman of the Texas & Pacific at Big Spring, Tex., has been appointed master mechanic, with headquarters at Ft. Worth, Tex.

F. W. BOARDMAN, master mechanic of the Texas & Pacific at Fort Worth, Tex., has accepted the position of master mechanic of the New Orleans Public Belt Railroad, with headquarters at New Orleans, La.

J. B. RAMBO, assistant road foreman of engines of the Pennsylvania, Eastern Region, has been appointed assistant trainmaster and road foreman of engines of the Philadelphia division.

Car Department

T. E. ANDERSON, car foreman of the Texas & Pacific at Ft. Worth, Tex., has been appointed general car foreman, with headquarters at Marshall, Tex.

LUTHER L. YATES, who retired as general superintendent car department of the Pacific Fruit Express on October 1, 1932, died at Monte Rio, Cal., on August 4.

Purchasing and Stores

WESLEY A. CLEM, assistant purchasing agent of the Reading, with headquarters at Philadelphia, Pa., has been appointed purchasing agent for that road and the Central of New Jersey, with the same headquarters.

A. R. MULLENS has been appointed assistant general storekeeper of the Oregon Short Line, the Oregon-Washington Railroad & Navigation Company and the Los Angeles & Salt Lake (all units of the Union Pacific System), with headquarters at Pocatello, Idaho.

JOHN D. LANDIS, purchasing agent of the Reading Company, with headquarters at Philadelphia, Pa., has been appointed assistant to president of that road and the Central of New Jersey, with the same headquarters. Mr. Landis wil lhave supervision over purchases and stores matters for both roads. Mr. Landis was born in Chester County, Pa., on June 29, 1859. He entered the service of the Reading as rodman in the engineering department in 1879. Two years later he was appointed chief clerk in the same department and in January, 1894, he became assistant purchasing agent. Mr. Landis was promoted to the position of purchasing agent in April, 1897. In July, 1918, he was appointed a member of the Regional Purchasing Committee of the United States Railroad Administration and the following year he again became purchasing agent for the Reading.

Obituary

EUGENE B. WHELAN, Omaha, Neb., died in that city on July 22 after a short illness. Prior to 1920 Mr. Whelan was employed in the mechanical departments of the Union Pacific, the Minneapolis & St. Louis and the Terminal Railroad of St. Louis, while during the last 14 years he devoted his entire time to the sale of the Whelan bi-pass valve.

Trade Publications

Copies of trade publications described in the column can be obtained by writing to the manufacturers. State the name and number of the bulletin or catalog desired, when mentioned in the description.

PACKINGS.—Over 60 different types of packings are described and illustrated in a 48-page catalog issued by Johns-Mansville, 22 East Fortieth street, New York.

ROLLER BEARINGS.—Catalog 12, issued by the Shafer Bearing Corporation, 6501 W. Grand avenue, Chicago, covers a wide variety of self-alining roller-bearing units for industrial and machine applications.

DIE HEADS.—General Purpose H & G self-opening die heads are described and illustrated in an 8 page bulletin issued by the Eastern Machine Screw Corporation, New Haven, Conn.

PYROMETERS.—The Illinois Testing Laboratories, Inc., 141 West Austin avenue, Chicago, has issued Bulletin No. 1727 describing "Alnor" pyrometers for measuring surface temperatures of either metallic or non-metallic materials.

POWER TRANSMISSION PRODUCTS.—The Boston Gear Works, Inc., 151 Lafayette street, New York, lists in Catalog 50 such power transmission products as gears, speed reducers, chain drivers, ball bearings, etc.

PNEUMATIC TOOLS.—"The World's Most Popular Pneumatic Tools" are listed in the eight-page bulletin (2037-A) issued by the Ingersoll-Rand Company, 11 Broadway, New York. The new sizes of Multi-Vane drills and Multi-Vane push-throttle screw drivers and nut setters are listed for the first time in this bulletin.

WELDING INFORMATION.—The Linde Air Products Company, New York, has issued two booklets. The first, an eight-page pamphlet entitled "Oxwelding Corrosion-Resisting Steels," contains much instructive data on welding stainless and alloy steel. The other, a twelve-page pamphlet entitled "Design of Jigs and Fixtures," deals with the design of jigs and fixtures for welding. This pamphlet is fully illustrated.

PLUG TYPE VALVES.—An eight-page illustrated booklet descriptive of plug type "Ferrenewo" and "Renewo" valves for throttling, drain and other service requiring maximum resistance to destructive action on valve-seat bearings has been issued by the Lunkenheimer Company, Cincinnati, Ohio.

BYERS GENUINE WROUGHT IRON PLATES.—The A. M. Byers Company, Pittsburgh, Pa., has published a 16-page attractively printed booklet bearing this title which shows the many applications of Byers genuine wrought iron plates and sheets. A considerable part of the space in the booklet is taken up by a large number of photographs illustrating the various ways that these plates and sheets have been used.

INGACLAD STAINLESS STEEL.—A 16-page booklet entitled "Manual of Welding and Fabricating Procedures for IngAclad Stainless Clad Steel" has been issued by the Ingersoll Steel & Disc Company, 310 South Michigan avenue, Chicago. The booklet takes up, step by step, the various methods of welding, soldering, lock seaming, riveting, heat treating, etc., encountered in fabricating products of stainless clad steel and contains many diagrams to guide the fabricator in working with the material.

LINDE PRODUCTS.—"101 Uses for the Air-Acetylene Flame" and "The Maintenance of Reciprocating Parts" are the titles of booklets issued by the Linde Air Products Company, 205 East Forty-Second street, New York. The former, which points out that the air-acetylene flame does not take the place of the oxy-acetylene flame but serves as a supplementary tool for use where lower flame temperatures are required, describes the outfits necessary where soldering, brazing or heating operations are involved. The latter booklet deals with the application by the oxy-acetylene process of wear-resisting bronze to the wearing surfaces of sliding parts.